# JOURNAL OF DAIRY SCIENCE

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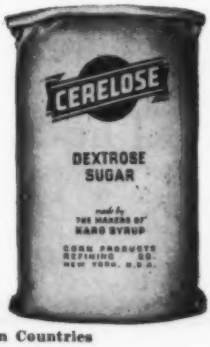


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JOURNAL OF DAIRY SCIENCE

VOLUME XXVI JULY, 1943 NUMBER 7

# EFFECT OF SOME SILAGES ON THE COPPER TOLERANCE OF PASTEURIZED MILK

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*Bureau of Dairy Industry, United States Department of Agriculture*

## INTRODUCTION

During the past few years a number of research workers have studied the relation of the feed of the cow to the development of an oxidized flavor in milk.

Garrett (4) reported that green grasses and legumes, preserved as silage or artificially dehydrated, are especially desirable for late winter and early spring feeding in preventing oxidized flavor. Bartlett, Garrett, Reece, and Hartman (1) reported that the feeding of properly ensiled molasses grass silage is a most excellent practical means of producing milk which is highly resistant to the development of oxidized flavor and that immature grasses and legumes ensiled in other ways probably will give results which are as satisfactory.

Garrett, Hartman, and Arnold (5) found that feeding grass silage prevents the development of oxidized flavor in milk when it is not contaminated with copper and greatly retards the development and lessens the intensity when soluble copper is added. Later these same authors (6) concluded that molasses alfalfa silage is equal to or better than pasture in producing milk of fine flavor and high resistance to the development of oxidized flavor. Brown, Vanlandingham, and Weakley (3), concluded that feeding high-quality alfalfa hay together with alfalfa leaf meal greatly reduced or eliminated the tendency for metal-induced oxidized flavor to develop. They further concluded that feeding brown, leafy alfalfa hay resulted in a decreased carotene content in milk but did not increase the intensity of the oxidized flavor.

Brown, Thurston, and Dustman (2), had previously noted a considerable variation among individual cows with respect to the tendency for oxidized flavor to develop in their milks. Guthrie and Brueckner (7), however, found that the only indication of a relation between the feed of the cow and the production of milk capable of developing "oxidized" flavors was the tendency of most cows that produced milk which acquired these flavors in

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[1] Now on military leave.



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winter not to produce such milk in summer. They also found a variation in the intensity of the "oxidized" flavors which developed in the milk of many cows from different quarters of the udder. From this latter fact they state: "It would seem, inasmuch as there was a variation in the intensity of the 'oxidized' flavors developed in the milk from the different quarters of the same udder, that the dry feeds were not the sole cause of the development of these flavors."

In practically all of these studies the results were based on the degree of oxidized flavor present in milk to which a definite quantity of copper had been added and that had been stored for a given time. The results of the investigation reported herein are based on the quantity of copper it was necessary to add to the milk to cause the development of an oxidized flavor during 48 hours of storage. Obviously this quantity of copper would be slightly higher than the quantity the milk would tolerate without developing the oxidized flavor.

## EXPERIMENTAL PROCEDURE

### *Silages Fed*

*Alfalfa silages.*—First-cutting alfalfa was used, both for straight silage and for silage to which 4 per cent of molasses was added. The alfalfa for both silages was cut in the early bloom stage, from the same and from adjoining fields. Because of droughty conditions the alfalfa was short, some spots were partly bleached, and in some areas it was grassy or weedy. At the time of feeding, the straight silage contained 65.77 per cent of moisture and 67.4 micrograms of carotene per gram of dry matter; the molasses silage contained 66.27 per cent of moisture and 52.4 micrograms of carotene.

*Soybean silage.*—Silage was made from soybeans cut as the seeds were beginning to form. The crop was wilted slightly before it was ensiled and, at the time of feeding, the silage contained 68.6 per cent of moisture and 104.8 micrograms of carotene per gram of dry matter.

*Corn silage.*—Silage was made from hybrid dent corn, late planted, partially dented, lower leaves brown due to dry weather. At the time of feeding, the silage contained 71.68 per cent of moisture and 35.5 micrograms of carotene per gram of dry matter.

### *Cows and Feeding*

The alfalfa silages were fed to four Holstein and eight Jersey cows, that had been on pasture up to the time silage feeding began. During the latter part of the grazing season, however, the pasture was short and was supplemented with straight alfalfa silage. The cows were divided into two groups of six each. One group was fed molasses silage and the other group straight silage for a period of 6 weeks, after which the groups were reversed and feeding was continued for another 6 weeks.

The soybean and corn silages were fed to six Holstein and six Jersey cows. Prior to the feeding of these silages, six of the cows were receiving alfalfa hay, corn silage, and grain, three were receiving straight alfalfa silage and grain, and three were receiving molasses alfalfa silage and grain. The cows were divided into two equal groups and the silages interchanged for 6-week feeding periods as was done with the alfalfa silages.

All cows were fed all the silage they would consume, together with enough grain to meet their requirements according to the Haecker standard.

The grain fed with the alfalfa silages consisted of equal parts corn, oats, and bran, with 1 per cent salt. While the cows were on molasses alfalfa silage they consumed a daily average of 55.2 pounds of silage and 11.2 pounds of grain and produced a daily average of 25.7 pounds of milk averaging 4.6 per cent of butterfat. On the straight alfalfa silage they consumed a daily average of 51.2 pounds of silage and 11.5 pounds of grain and produced a daily average of 26.1 pounds of milk averaging 4.8 per cent butterfat.

The grain fed with soybean silage consisted of equal parts of corn, barley, and bran, plus 1 per cent of salt. That fed with corn silage consisted of corn, barley, bran, and linseed meal, plus 1 per cent of salt. While the cows were on soybean silage they consumed a daily average of 56.4 pounds of silage and 15.2 pounds of grain and produced a daily average of 31.4 pounds of milk averaging 4.67 per cent of butterfat. On corn silage they consumed a daily average of 57.6 pounds of silage and 15.1 pounds of grain and produced a daily average of 32.5 pounds of milk averaging 4.68 per cent of butterfat.

### *Milk Samples*

Samples of the milk were collected in brown 1-gallon bottles every 2 weeks. This gave three samples from each cow while she was on each of the silages, or a total of six samples from each cow. The milk was bottled and placed in ice water as soon as it was drawn, and then transported by truck from the Beltsville, Md., farm to the Washington laboratory, where it was pasteurized at 143° F. for 30 minutes and then cooled and bottled in ½-pint bottles. Care was taken to prevent the milk from being exposed to light while it was being bottled, pasteurized, and cooled.

Different quantities of copper (in the form of copper sulphate) were added to each ½-pint sample, except the control. It was then stored at approximately 0° C. (32° F.). The samples were judged for the presence of an oxidized flavor at 24 and 48 hours of storage, but only the results obtained at 48 hours are reported herein. The judging was done without knowledge as to which samples contained copper, the amount of copper they contained, the identity of the cow that produced the sample, or the silage she was fed.

RESULTS

GROUP 1.—*Molasses alfalfa silage followed by straight alfalfa silage.* Feeding molasses alfalfa silage for 6 weeks lowered the quantity of copper necessary to cause an oxidized flavor in the milk, produced by six cows, from an average of 0.43 p.p.m. to an average of 0.37 p.p.m. Feeding straight

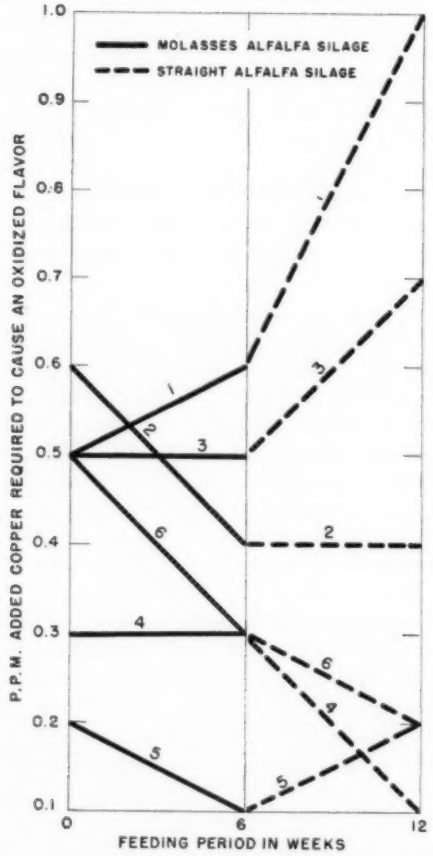


FIG. 1. Effect of feeding molasses alfalfa silage for 6 weeks and then straight alfalfa silage for 6 weeks on the copper tolerance of the milk produced.

alfalfa silage for 6 weeks, following the molasses silage, increased the quantity of copper from an average of 0.37 p.p.m. to an average of 0.43 p.p.m. There was no regular trend in the changes that occurred in the copper tolerance of the milk from individual cows, however. (See figure 1.) At the end of the molasses silage feeding period the copper requirement had not

changed for two cows, whereas for three cows it had decreased and for the other one it had increased. When straight alfalfa silage was fed for 6 weeks the copper requirement did not change for one cow, but it decreased for two and increased for the other three.

GROUP 2.—*Straight alfalfa silage followed by molasses alfalfa silage.* Feeding straight alfalfa silage for 6 weeks raised the quantity of copper

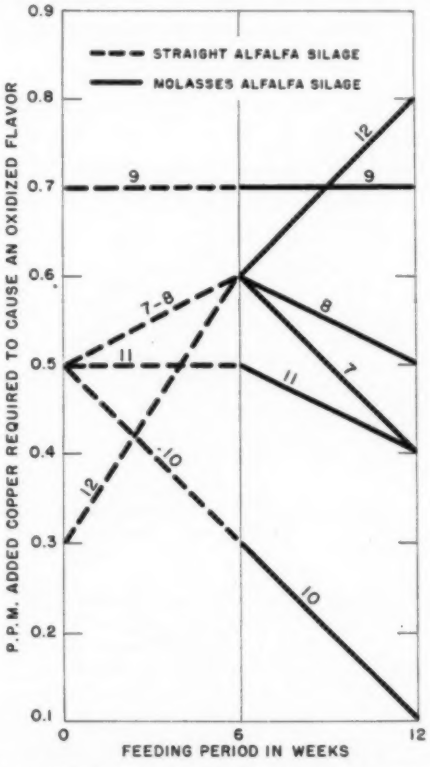


FIG. 2. Effect of feeding straight alfalfa silage for 6 weeks and then molasses alfalfa silage for 6 weeks on the copper tolerance of the milk produced.

necessary to cause an oxidized flavor in the milk, produced by six cows, from an average of 0.30 p.p.m. to an average of 0.33 p.p.m. Feeding molasses alfalfa silage for 6 weeks, following the straight silage, lowered the quantity of copper from an average of 0.33 p.p.m. to 0.29 p.p.m. Figure 2 shows that the same irregular trend in the copper requirement for individual cows occurred when the silages were fed in this order as when they were fed in the reverse order. When the straight alfalfa silage was fed the copper

requirement remained constant for two cows, increased for three cows, and decreased for one. When the molasses alfalfa silage was fed the copper requirement increased for one cow, decreased for four, and remained constant for the other cow.

GROUPS 3 AND 4.—*Soybean silage followed by corn silage and corn silage followed by soybean silage.* Feeding either soybean silage or corn silage for 6 weeks did not change the average quantity of copper necessary to cause an oxidized flavor in the milk. Following the soybean silage with corn silage

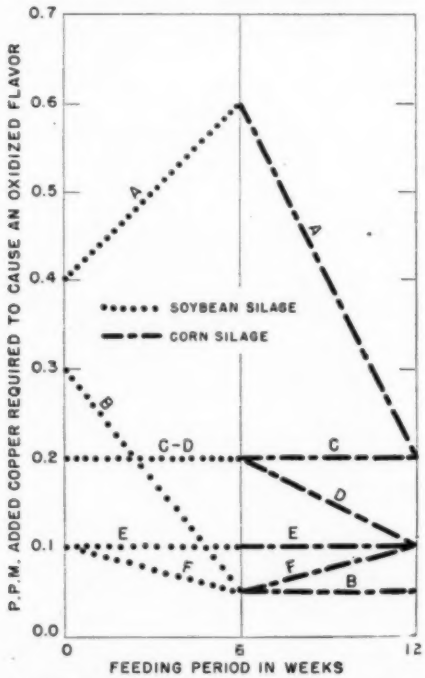


FIG. 3. Effect of feeding soybean silage for 6 weeks and then corn silage for 6 weeks on the copper tolerance of the milk produced.

lowered the copper requirements, however, from an average of 0.20 p.p.m. to an average of 0.12 p.p.m. Likewise, following the corn silage with soybean silage lowered the copper requirement from an average of 0.37 p.p.m. to an average of 0.34 p.p.m. Figures 3 and 4 show that the variations in the copper tolerance of the milk from individual cows were as irregular when these silages were fed as when the alfalfa silages were fed.

## SUMMARY

Feeding molasses alfalfa silage for 6 weeks decreased the average quantity of copper required to produce an oxidized flavor in the milk, by 0.06

p.p.m. in one trial and 0.04 p.p.m. in the other. Feeding straight alfalfa silage increased the average quantity of copper required to cause an oxidized flavor in the milk, by 0.06 p.p.m. in one trial and 0.03 p.p.m. in the other.

Feeding corn silage for 6 weeks, after feeding soybean silage for 6 weeks, lowered the average copper tolerance of the milk by 0.08 p.p.m.; and feeding soybean silage for 6 weeks, after feeding corn silage for 6 weeks, lowered the average copper tolerance of the milk by 0.04 p.p.m.

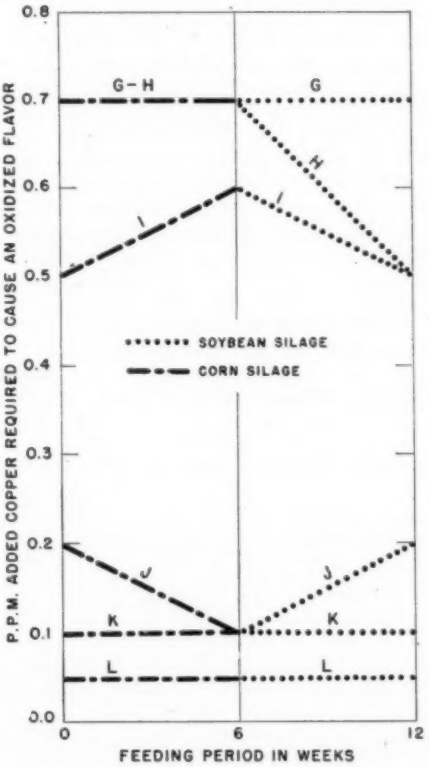


FIG. 4. Effect of feeding corn silage for 6 weeks and then soybean silage for 6 weeks on the copper tolerance of the milk produced.

These results might be of slight significance were it not for the following facts:

1. The milk from individual animals frequently varied as much as 0.1 p.p.m. in copper tolerance, from one sampling period to the next during the same feeding period.

2. There was no uniform tendency for any of the silages to increase or decrease the copper tolerance of the milk produced. In each of the feeding

periods there were individual cows that produced milk in which the copper tolerance remained constant, some that produced milk in which the copper tolerance increased, and others that produced milk in which it decreased.

## CONCLUSION

The feeding of molasses-alfalfa silage, straight alfalfa silage, soybean silage, or corn silage has no significant effect on the copper tolerance of the milk produced.

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# THE EFFECT OF VARIOUS DEGREES OF FOREWARMING UPON THE HEAT STABILITY OF MILKS OF DIFFERENT SOLIDS CONCENTRATIONS

B. H. WEBB, R. W. BELL, E. F. DEYSHER AND G. E. HOLM

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The effect of the concentration upon the stability of milks to heat has been reported by Holm, Deysher and Evans (2) and by Webb and Holm (7). Their results were obtained with milks in which the solids-not-fat concentrations were equal to or less than that of commercial evaporated milk and indicate the relationship between the concentrations of solids in these milks and the times and temperatures of heating needed to bring about coagulation. The forewarming treatment employed was that customarily used in the manufacture of evaporated milk. Within the range of the solids concentrations studied the time required to initiate coagulation in each product increased logarithmically with decreases in the temperature. Wright (8) in a study of the solubility of milk powder at temperatures below 100° C., found a similar relationship at concentrations of 86 per cent milk-solids-not-fat.

Leighton and Deysher (4) studied the effect of different degrees of forewarming and noted that the use of temperatures greater than 95° C. for 10, 20, or 30-minute periods resulted in a decreased heat stability of concentrated milks prepared normally.

The hydrogen ion concentration of milks increases with each increase in milk solids content. Howat and Wright (3) call attention to the probable destabilizing effect of high concentrations of hydrogen ions which accompanies every increase in milk solids concentration.

Recent work by Webb and Bell (6) has shown that high-temperature short-time forewarming of milk increases the stability of its concentrated product of 26 per cent solids content from 2 to 6 times that of the sample forewarmed in the customary manner. It seemed probable that heat treatment of this type would make possible the preparation and sterilization without coagulation of milks of solids concentrations greater than 26 per cent.

Studies of the effect of concentration of solids upon the heat stability of milks forewarmed to various degrees of time and temperature will be reported here.

## EXPERIMENTAL

The methods and equipment used in this work were in general the same as those recently described by Webb and Bell (6). Whole milk from the Beltsville herd of the Bureau of Dairy Industry was standardized to a fat to

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solids-not-fat ratio of 1 to 2.29. The control samples were forewarmed to 95° C. in a steam-jacketed kettle with mechanical agitation and maintained at this temperature 10 minutes. The test samples were forewarmed in a Mallory heater (5) which required 3 seconds to bring the milk up to the chosen temperature and 3 seconds to cool it. The holding time was varied from zero time to 16 minutes. Different holding periods (except for data of figure 1) were obtained by forcing the milk at the rate of 1.5 gallons per minute through one or more of the I.D. stainless steel tubes described below:

| Stainless tube | Internal diameter | Length | Capacity | Holding period obtained |
|---|---|---|---|---|
| | *inches* | *feet* | *gallons* | *seconds* |
| No. 1 | 0.18 | 330 | 0.4 | 15 |
| No. 2 | 2.00 | 7 | 1.5 | 60 |
| No. 3 | 4.50 | 7 | 6.0 | 240 |

Only the heating and cooling tubes were used when zero holding time was desired.

After the milk was forewarmed, it was concentrated in a stainless steel vacuum pan to 32 per cent to 37 per cent solids content, heated to 60° C., homogenized at a pressure of 2500 pounds per square inch and cooled. Small quantities of this milk were reduced with water to the desired solids content. The time required to initiate coagulation in these samples at 115° C. was then determined by heating them in small cans in a pilot sterilizer.

## RESULTS

The effect of varying the time of forewarming a control sample at 95° C. upon the heat stability of its concentrated product is shown in table 1. The differences produced by changing the forewarming time were small when compared with the differences that were obtained by means of short-time-high-temperature forewarming.

TABLE 1

*Effect of time of forewarming a control sample of milk at 95° C. (203° F.) in a steam-jacketed hotwell upon the heat stability of its concentrated product*

| Solids content of milk | Time to initiate coagulation at 115° C. (239° F.) | | | | |
|---|---|---|---|---|---|
| | No holding time | Forewarmed 10 minutes | Forewarmed 20 minutes | Forewarmed 30 minutes | Forewarmed 40 minutes |
| % | *min.* | *min.* | *min.* | *min.* | *min.* |
| 26.0 | 35 | 31 | 25 | 24 | 23 |
| 30.0 | 26 | 23 | 25 | 23 | 21 |
| 32.5 | 15 | 19 | 22 | 22 | 20 |

In figure 1 are shown the heat stability values obtained with two samples of a milk forewarmed at 95° C. for 10 minutes and 150° C. for 25 seconds, respectively, and each reduced to concentrations of solids ranging from

13 per cent to 33 per cent. The 25-second holding period was obtained by decreasing the rate of flow of the milk in the 15-second holding tube. For these samples, the decrease in the time of coagulation with each 1 per cent increase in solids concentration up to 25 per cent was practically a constant.

As the concentrations were increased to values greater than 25 per cent the stability of the samples from the milk forewarmed at 150° C. for 25 seconds decreased more rapidly than did the stability of other samples of the same milk forewarmed at 95° C. for 10 minutes.

Of especial interest are those milks of concentrations greater than 26 per cent. The effect of various forewarming treatments on the stability of different milks of these concentrations is shown in figures 2 and 3. The data for each sub-figure were obtained from a different batch of milk but all curves in each sub-figure were drawn from data obtained with the same milk.

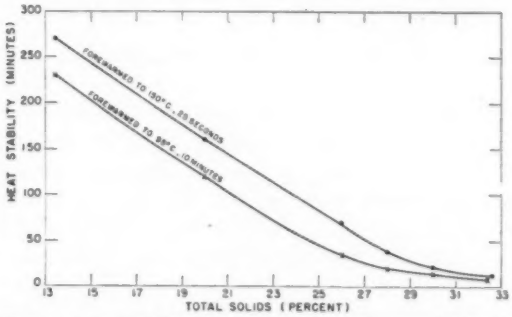


FIG. 1. Effect of two methods of forewarming milk upon the heat stability of its concentrated product. Milk-solids-not-fat = total solids × 0.696. Heat stability refers to the time necessary to initiate coagulation at 115° C. (239° F.).

These results indicate, as did those of figure 1, that relatively greater stability is imparted to the milk at low concentrations of solids than at the higher concentrations.

When the high-temperature-short-time forewarming temperature was low or excessively high or when the holding period was too short, less stability was observed in the test than in the control samples at the high solids concentrations. With the Mallory heater, forewarming treatments were found for each of the milks of figures 2 and 3 which produced less as well as more stability than that exhibited by the control samples at concentrations above 28 or 30 per cent solids content.

The effect of high-temperature-short-time forewarming upon a milk with developed acidity differed only in degree from that upon the same milk of lower acidity. This is shown in figure 4. The aged milk had a lower heat stability but the relative position of the curves was unchanged. Likewise stabilizing salts altered only in degree the heat-stability relationships in the milk samples used in this work. The effect of calcium and phosphate

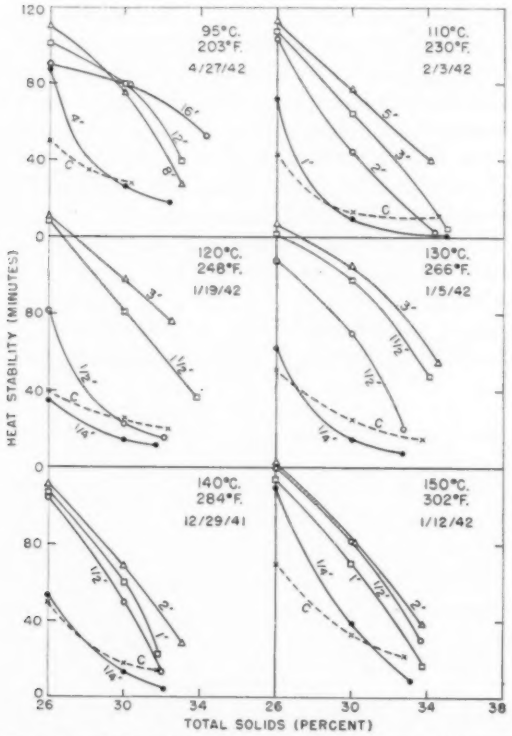


FIG. 2. Effect of variations in the time and temperature of forewarming upon the heat stability of concentrated milks of different solids content. The control sample forewarmed at 95° C. for 10 minutes is marked "C." All other samples were forewarmed in the Mallory heater and held for the number of minutes indicated for each curve. The forewarming temperature for each series is indicated. Milk for each sub-figure was obtained on the date shown. Heat stability refers to the time necessary to initiate coagulation at 115° C. (239° F.).

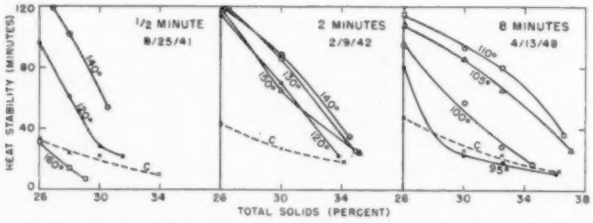


FIG. 3. Effect of variations in the temperature of forewarming upon the heat stability of concentrated milks of different solids content. The control samples forewarmed at 95° C. for 10 minutes are marked "C." Forewarming time was different for each of the three batches of milk. Heat stability refers to the time necessary to initiate coagulation at 115° C. (239° F.).

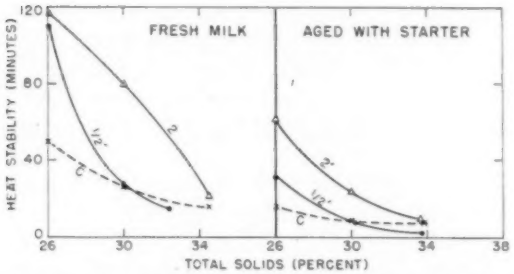


FIG. 4. Effect upon heat stability of forewarming fresh and aged milk. The control sample forewarmed to 95° C. for 10 minutes is marked "C." The forewarming treatment for other samples was 130° C. for ½ and 2 minutes. The fresh milk was aged 2 hours at 37° C. with *S. lactis* starter, the acidity changing from .18 to .21 per cent. Heat stability refers to the time necessary to initiate coagulation at 115° C. (239° F.).

stabilizers when added to a milk forewarmed to different temperatures is shown in figure 5.

Several experiments were conducted to determine whether the stabilizing effect of the heating in the Mallory heater was derived solely from the temperature the milk attained in the heater. Milks were heated to 95° C. and held for 10 minutes by means of four different heating units: The steam-jacketed hotwell in which the control was always forewarmed, the high-temperature-short-time heater, and two tubular heaters. The time required to attain 95° C. in these heaters was: Hotwell, 13 minutes; high-temperature-short-time heater, 3 seconds; tubular heater No. 1, 35 seconds; and tubular heater No. 2, 3 minutes. It was necessary to recirculate milk through heater No. 2 several times before a temperature of 95° C. could be attained. Table 2 contains some results of these experiments. Rapid preheating to 95° C. increased the heat stability of most milks above that imparted to

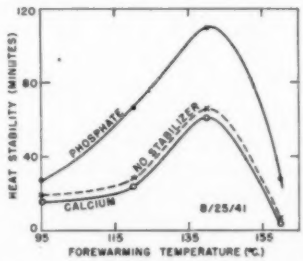


FIG. 5. Effect upon the heat stability of concentrated milk of the addition of stabilizing salts to milk forewarmed to different temperatures for 30 seconds. The total solids content of the milk was 30 per cent. The milks containing stabilizers received the equivalent of 13 oz. $Na_2HPO_4 \cdot 12\,H_2O$ or 1.3 oz. $CaCl_2$ per 1000 pounds of evaporated milk. Heat stability refers to the time necessary to initiate coagulation at 115° C. (239° F.).

TABLE 2

*Effect of forewarming milk at 95° C. (203° F.) for 10 minutes in different types of heaters upon the heat stability of its concentrated product*

| Date 1942 | Solids content of milk | Time to initiate coagulation at 115° C. (239° F.) | | | |
|---|---|---|---|---|---|
| | | Hotwell (control) | Mallory heater | Tubular heater #1 | Tubular heater #2 |
| | % | *min.* | *min.* | *min.* | *min.* |
| 4/ 7 | 26.0 | 37 | ..... | ..... | 37 |
| | 32.5 | 10 | ..... | ..... | 15 |
| 4/10 | 26.0 | 34 | 83 | ..... | ..... |
| | 32.5 | 12 | 14 | ..... | ..... |
| 5/ 4 | 26.0 | 30 | ..... | 33 | ..... |
| | 32.5 | 19 | ..... | 25 | ..... |
| 5/ 5 | 26.0 | 30 | ..... | 37 | ..... |
| | 32.5 | 16 | ..... | 16 | ..... |
| 5/18 | 26.0 | 30 | 40 | ..... | ..... |
| | 32.5 | 25 | 28 | ..... | ..... |
| 6/ 8 | 26.0 | 31 | 36 | ..... | ..... |
| | 32.5 | 19 | 26 | ..... | ..... |

samples heated slowly in the hotwell to the same temperature. The high-temperature-short-time heater was more effective in this respect than were the tubular heaters.

## DISCUSSION

These basic relationships between the conditions of forewarming fresh milk and the heat stability of its concentrated product can probably be applied to all milks. Heat stabilities of milks other than those used in this investigation should show the same general relationship, although differing in absolute values. Extensive trials conducted in a midwestern evaporated milk plant produced results similar to those reported here.

A complete set of time-temperature data on a milk would be necessary before the treatment yielding maximum stability could be determined. When a high-temperature treated milk was less stable than the control sample, a lower temperature and a longer holding time generally improved it. Some factory milks react as did the cultured milk of figure 4. This may not signify that the milk is of high acidity but that environmental factors such as feed, condition of the cows, or weather have affected it. For such a milk the curve of the high-temperature forewarmed sample sometimes crosses the control curve at a solids concentration below 26 per cent. To improve the stability of this milk a lower forewarming temperature and a longer holding time than those used for the samples of figure 4 would be effective.

The results recorded in table 2 offer evidence that rapid heating of the raw milk to forewarming temperatures, especially where the coming up time is only a few seconds, has a specific stabilizing effect. Enough heaters of different types were not available to permit a conclusive study of this point. In general, milks which reached the forewarming temperatures most

rapidly were the most stable after concentration. Comparisons could be made only at temperatures below 100° C.

High-temperature forewarming should be useful in evaporated milk manufacture. But a quick, accurate heat stability test on the raw milk which would indicate optimum forewarming conditions is still urgently needed.

Improper forewarming may produce evaporated milk of poor body. Stabilizers may be used to control body but there is some indication that a few high-temperature-forewarmed milks will not react favorably to body building stabilizers. The body of a milk may also be controlled by mixing the proper quantities of normally and high-temperature-forewarmed milks.

Low-heat stability can no longer be considered a factor which might limit evaporated milk to 26 per cent solids content. High-temperature forewarming of Beltsville milk increased the solids content of the product which could be sterilized without coagulation to 5 per cent above that of the normally-forewarmed control samples. To attain such an improvement it was necessary to use the optimum heat treatment, which for most samples was to forewarm at 120° C. for 3 to 4 minutes. It is probable that the average condensery milk could be so improved by high-temperature forewarming as to allow an increase of 2 to 5 per cent in the solids content of the finished evaporated milk. When control samples of Beltsville milk were forewarmed to 95° C. for 10 minutes, concentrations of 30 to 32 per cent solids could be sterilized with the production of a smooth body. Subjection of this milk to rapid forewarming at 120° C. for 3 minutes made it possible to process milks of 35 to 37 per cent solids content.

The effects of forewarming treatments of milk on the color of its evaporated product will be discussed in the following paper (1).

## SUMMARY

1. Whole milk quickly forewarmed at temperatures between 110° C. (230° F.) and 150° C. (302° F.) and held for the optimum time period for that milk (½ to 5 minutes) exhibited much greater heat stability after concentration to 26 per cent solids content, or higher, than did those samples of the same milk forewarmed to 95° C. (203° F.) for 10 minutes in the conventional manner.

2. The heat stability of concentrated milks which before concentration were forewarmed at high temperatures and of those forewarmed at 95° C. for 10 minutes decreased at the same rates as the solids content was increased up to 25 per cent. At higher solids concentrations the heat stabilities of the milks forewarmed quickly at the high temperatures more closely approached those of the control samples forewarmed at 95° C. (203° F.) for 10 minutes. Finally a concentration (32 to 37 per cent) was reached, different for each milk and each heat treatment, at which the heat stabilities of the test and control samples were about the same.

3. The general heat stability relationships of milks subjected to different forewarming treatments were not affected by the development of acidity in fresh milk or by the addition of stabilizing salts to concentrated milks; the difference in stability caused by acid or salts was one of degree and it affected the general heat stability level rather than the stability interrelationships of milks forwarmed one way or another.

4. From a heat-stability viewpoint it should be commercially possible to manufacture evaporated milk of approximately 32 per cent total solids content. A good grade of milk should be quickly forewarmed to about 120° C. (248° F.) and held 3 to 4 minutes, then drawn into the vacuum pan and handled in the usual way. The optimum forewarming treatment which will give the heat stability and body desired in the finished product can be best determined through experience with high-temperature-forewarming procedures on each individual milk supply.

ACKNOWLEDGMENT

The authors are indebted to Mr. C. F. Hufnagel of the Laboratory Staff for assistance with much of the manufacturing work required by this project.

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# RELATIONSHIPS BETWEEN HIGH TEMPERATURE FOREWARMING AND THE COLOR AND HEAT STABILITY OF EVAPORATED MILKS OF DIFFERENT SOLIDS CONTENT

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In the course of experiments in the Bureau of Dairy Industry laboratories it was learned that the heat stability of concentrated milk can be greatly increased by heating the whole milk above its boiling point and maintaining the temperature for a suitable period (4). Thus it was shown that in the making of evaporated milk the stability desired during the sterilizing step can be obtained without adding stabilizing salts.

In the above-mentioned work, milk was forewarmed to temperatures greatly in excess of the temperature (95° C. or 203° F.) usually employed commercially. One question, therefore, was whether its evaporated product would have a darker color than the evaporated product of a milk forewarmed in the usual manner. Research was designed to answer this question. This report includes data on the color of evaporated milks made from milk forewarmed over a wide range of temperatures for 15 seconds to 16 minutes.

## METHODS AND MATERIALS

*Preparation of samples.* The methods and equipment used in the preparation of the samples have been described elsewhere (4).

The time required to heat a control sample to 95° C. was 13 minutes. The time elapsing from the end of the 10-minute holding period until all the hot milk was in the evaporator under a high vacuum was 5 minutes.

Sterilization was effected by heating the homogenized and standardized concentrate in small cans to 115° C. (239° F.) and maintaining this temperature 18 minutes before cooling quickly to room temperature.

*Methods of measuring color.* Nickerson (2) has described a method of measuring the color of agricultural products. She says: "Color may be completely specified in terms of three attributes: Hue, lightness,[1] and chroma. Hue is the attribute which permits colors to be classed as reddish, yellowish, greenish, or bluish; lightness is the attribute by which a light color is distinguished from a dark color; and chroma is the attribute by which a strong color may be distinguished from a weak color. Each of these attributes may be measured on a scale of psychologically equal steps."

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[1] The term "lightness" is fast replacing the more awkward term "brilliance." Both terms are synonymous with the Munsell term "value."

Relatively few investigators, however, have measured the color of evaporated milk. The color standards prepared by Webb and Holm (5) for measuring the color of evaporated milks were still available in the Bureau's laboratories when the present work was begun in 1941. The hue, lightness, and chroma values of these standards had changed only a little. But for the work reported herein, because it was desired to measure small differences in each of these three color attributes, facilities were assembled and conditions standardized for making direct color measurements by the method described by Nickerson.

Colors of standard notation made from permanent pigments were obtained from the Munsell Color Company, Baltimore, Maryland. These paper standards were designated 7 Yellow Red 7.4/14 (#1744); 7.5 Yellow 9/10 (#1718); Neutral 5/ (gray #1173); and Neutral 9.8/ (white #E5462). Colorimetric data for these four paper standards were based on spectrophotometric measurements made by the National Bureau of Standards.

Maxwell disks, 4.5 inches in diameter, were prepared so that the four color standards might be slipped together with a portion of each visible. These were mounted on the shaft of a motor and rotated at a speed great enough to avoid flicker. Colors within the desired range were obtained by increasing or decreasing the exposed areas of these disks. A Bausch and Lomb comparator eyepiece was used to facilitate matching, the light reflected from the sample being directed into one-half of the matching field and the light from the standard disks into the other half. Two Macbeth lamps supplied artificial daylighting at a color temperature of 7600–8000° K. Lighting and observing conditions closely approximated 45° illumination, normal viewing.[2]

The measurement is made by adjusting the exposed areas of the disks until on whirling there is a match with the color of the experimental sample when both are viewed through the eyepiece. The hue, lightness, and chroma values are then determined from the percentage of each exposed color by means of a formula and color charts based on Munsell—I.C.I. conversion charts published by Nickerson (3).

In order to understand this method of measuring color, it is necessary to study the three-dimensional relationships of color (1, 2, 3).

Five hues—red, yellow, green, blue, and purple—form the basis for the hue circle. Midway between them are the intermediate hues and each has a numerical notation ranging from 0 to 10. The hue of the unsterilized- and sterilized-concentrated milks used in this work was within the yellow range.

The lightness scale begins at 0, which is absolute black, and progresses through equal steps to a neutral gray of middle lightness at 5 and from there to 10, which is absolute white. The lightness of unsterilized-concentrated

[2] The authors are indebted to Miss Nickerson for much of this equipment, the selection and checking of the disks, and instruction in their use.

milk of 26 per cent solids content is about 9.60. That of its sterilized (evaporated) product may be as low as 8.75.

The notation for chroma begins at neutral gray, which is 0, and progresses through equal steps to a strong color. A weak color will have a notation of 1, 2, or 3, while strong colors may go beyond 10. Decimals are used for expressing fine differences in hue, lightness, and chroma. In noting the color of a milk, it must be remembered that with increasing color the hue and lightness values decrease while the chroma value increases. Homogenized-concentrated milk of 7.9 per cent fat and 18.0 per cent milk-

TABLE 1

*Relationship between forewarming treatment of milk and the color of its evaporated (sterilized) product*

| Date 1942 | Forewarming treatment | | Color | | |
|---|---|---|---|---|---|
| | °C. | Minutes | Hue | Lightness | Chroma |
| 4–27 | 95 | 10 | 2.75Y | 9.00 | 2.85 |
| | 95 | 4 | 2.75Y | 9.07 | 2.55 |
| | 95 | 8 | 2.85Y | 9.05 | 2.60 |
| | 95 | 12 | 3.00Y | 9.09 | 2.60 |
| | 95 | 16 | 2.85Y | 9.05 | 2.60 |
| 4–13 | 95 | 10 | 2.90Y | 8.90 | 2.90 |
| | 95 | 8 | 3.00Y | 9.01 | 2.55 |
| | 100 | 8 | 3.00Y | 9.01 | 2.55 |
| | 105 | 8 | 2.90Y | 8.99 | 2.70 |
| | 110 | 8 | 2.80Y | 8.97 | 2.90 |
| 2–3 | 95 | 10 | 3.95Y | 8.82 | 3.00 |
| | 110 | 1 | 3.70Y | 8.98 | 3.10 |
| | 110 | 2 | 3.80Y | 8.95 | 3.10 |
| | 110 | 3 | 3.70Y | 8.92 | 3.10 |
| | 110 | 5 | 3.95Y | 8.86 | 3.00 |
| 1–6 | 95 | 10 | 3.90Y | 9.00 | 2.75 |
| | 120 | 1 | 3.90Y | 9.09 | 2.80 |
| | 120 | 2 | 4.00Y | 9.06 | 3.00 |
| | 120 | 3 | 3.85Y | 8.98 | 3.15 |
| | 120 | 5 | 4.00Y | 8.99 | 3.30 |
| 2–9 | 95 | 10 | 3.45Y | 8.97 | 2.90 |
| | 120 | 2 | 3.35Y | 8.98 | 2.75 |
| | 130 | 2 | 3.40Y | 8.87 | 3.20 |
| | 140 | 2 | 2.95Y | 8.78 | 3.80 |
| | 150 | 2 | 1.80Y | 8.25 | 4.60 |

solids-not-fat content may have a color of 9.00Y/9.55/1.30 (hue/lightness/chroma) while its color after sterilization may be 3.30Y/9.00/2.85. The first set of figures corresponds to 1 per cent yellow red, 22 per cent yellow, 0 per cent neutral gray, and 77 per cent white, and the second to 24 per cent yellow red, 18 per cent yellow, 5 per cent neutral gray, and 53 per cent white, of the color disks previously designated. Sterilization decreases the percentage of yellow and white and increases the percentage of yellow red and neutral gray. Or, expressed in terms of the three color attributes, sterilization changes the hue toward yellow red, decreases the lightness, and increases the chroma.

## EXPERIMENTAL RESULTS

*Temperature and time of forewarming.* In these experiments (table 1) the control or reference color (first in each batch) was that of an evaporated sample in the preparation of which the milk was forewarmed to 95° C. and held 10 minutes before the hot milk was drawn into the evaporator. All other samples were made from milk forewarmed by the high-short method (4). The composition of the samples was very nearly that called for by U. S. standards for evaporated milk—7.9 per cent fat and 26.0 per cent total solids.

TABLE 2

*Relationship between evaporated milks of similar color but made by different forewarming treatments and their heat stability or time necessary to initiate coagulation at 115° C.*

| Forewarming treatment | | Milk solids 26.0% | | | |
|---|---|---|---|---|---|
| | | Color | | | Heat stability |
| °C. | Seconds | Hue | Lightness | Chroma | Minutes |
| 95 | 600 | 3.3Y | 9.01 | 2.5 | 23 |
| 109 | 480 | 3.2Y | 9.06 | 2.5 | 95 |
| 120 | 180 | 3.0Y | 9.01 | 2.8 | 105 |
| 129 | 75 | 3.3Y | 9.02 | 2.6 | 98 |
| 138 | 30 | 3.1Y | 9.03 | 2.7 | 96 |
| 145 | 15 | 3.0Y | 8.92 | 2.8 | 74 |
| | | Milk solids 30.0% | | | |
| 95 | 600 | 3.1Y | 8.94 | 3.2 | 13 |
| 109 | 480 | 3.2Y | 8.99 | 3.1 | 69 |
| 120 | 180 | 3.0Y | 8.94 | 3.3 | 85 |
| 129 | 75 | 3.1Y | 8.97 | 3.2 | 57 |
| 138 | 30 | 3.0Y | 8.95 | 3.4 | 43 |
| 145 | 15 | 3.0Y | 8.92 | 3.4 | 15 |
| | | Milk solids 32.5% | | | |
| 95 | 600 | 3.0Y | 8.77 | 3.5 | 8 |
| 109 | 480 | 3.0Y | 8.79 | 3.4 | 52 |
| 120 | 180 | 2.8Y | 8.89 | 3.6 | 62 |
| 129 | 75 | 3.0Y | 8.83 | 3.4 | 21 |
| 138 | 30 | 2.9Y | 8.78 | 3.6 | 13 |
| 145 | 15 | 2.9Y | 8.78 | 3.6 | 6 |

As expected, the results showed that forewarming can be continued for a longer time at a low temperature than at a high one without intensifying the color of the evaporated product. These data show that any one of many combinations of temperature and time of forewarming may be used without affecting adversely the color of evaporated milk. The relationship between these forewarming treatments and the heat stability of the concentrated milk under sterilizing conditions has been shown (4). The data given therein and those presented in table 2 indicate that in the making of evaporated milk the concentrate may be greatly stabilized to heat by employing the appropri-

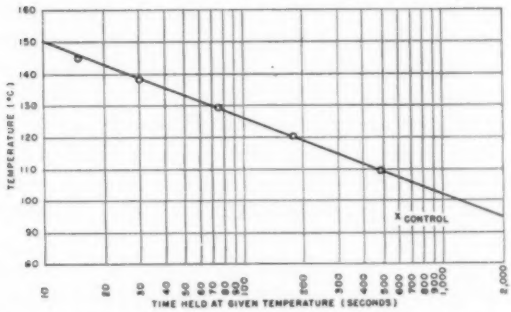


FIG. 1. Temperature-time forewarming relationships for obtaining a similar color in evaporated milks.

ate forewarming condition, and that in so doing the color of the commercial product is not affected adversely. In fact, the color may be even more desirable than that of evaporated milk made from another portion of the same whole milk forewarmed in the usual way at 95° C. for 10 minutes.

With a similar color in these samples (table 2) the relationship between forewarming time and temperature may be shown graphically. This has been done in figure 1. Any high-temperature short-time forewarming treatment which fell below this curve produced in the evaporated milk a lighter and weaker color than that of the control.

According to this curve, for each 10° C. decrease in forewarming temperature the holding period was increased approximately 2.5 fold without causing an increase in the color of the evaporated product.

The data of table 2 have been utilized in the preparation of figure 2 to present the relationship between combinations of temperature and time of forewarming and heat stability when the former have a similar effect on the

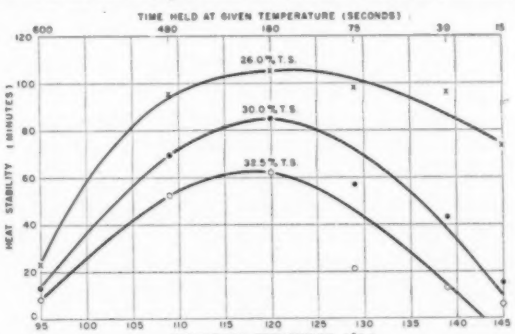


FIG. 2. Relationship between heat stability and forewarming temperature (°C.) for enough time (see figure 1) to have a similar effect on the color of evaporated milk. Heat stability refers to the time necessary to initiate coagulation at 115° C. (239° F.).

color of the evaporated milk. Thus it is shown that with the high-short forewarming equipment, maximum heat stability of the concentrated milks was obtained by forewarming at 120° C. with a holding time of 3 minutes.

*Solids content and color of evaporated milks.* As the solids content of the evaporated milk of table 2 was increased from 26 per cent to 30 per cent and 32.5 per cent, the hue became more yellow red, lightness decreased and chroma increased. The greatest changes were in chroma. There was a relatively large decrease in lightness on increasing the solids from 30 per cent to 32.5 per cent.

If evaporated milk that contains more than the usual amount of solids is diluted until it has the composition of the U. S. standard product, then

TABLE 3

*Effect on color of diluting high solids evaporated milks to 26 per cent total solids content*

| Forewarming treatment | | Total solids (undiluted) | Color | | | Total solids (diluted after sterilization) | | Color | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | Time | | Hue | Lightness | Chroma | From | To | Hue | Lightness | Chroma |
| °C. | mins. | % | | | | % | % | | | |
| 95 | 10 | 26.0 | 3.20Y | 9.10 | 2.30 | ..... | ..... | ..... | ..... | ..... |
| | | 30.0 | 3.10Y | 9.00 | 2.95 | 30.0 | 26.0 | 3.15Y | 9.03 | 2.65 |
| | | 32.5 | 3.00Y | 8.95 | 3.15 | 32.5 | 26.0 | 3.00Y | 9.01 | 2.80 |
| 115 | 8 | 26.0 | 2.75Y | 8.97 | 3.15 | ..... | ..... | ..... | ..... | ..... |
| | | 30.0 | 2.65Y | 8.84 | 3.50 | 30.0 | 26.0 | 2.60Y | 8.91 | 3.30 |
| | | 32.5 | 2.50Y | 8.79 | 3.80 | 32.5 | 26.0 | 2.50Y | 8.89 | 3.40 |

the greater color of these milks is in direct proportion to their greater solids content. Data on this point are presented in table 3. The homogenized-condensed-whole milk contained 34 per cent solids. The samples for sterilization were prepared from this milk by adding the necessary amount of water. All the samples were sterilized together at the same time.

It will be seen in table 3 that adjustment after sterilization to 26 per cent total solids content by the addition of water did not produce milks that were as light in color as those which had been adjusted to 26 per cent solids content before they were sterilized. When the sterilized milks were diluted there was practically no change in hue, lightness was increased, and chroma decreased. Strength was the color attribute most affected.

## DISCUSSION

No attempt was made to obtain special milk except to make sure that it contained more than 3.9 per cent fat. Each batch was standardized with

skim milk to a fat to solids-not-fat ratio of 1.00 to 2.29. All control samples were prepared in the same way with identical equipment and yet, as will be noted in table 1, the control of February 3 had a hue of 3.95Y, lightness 8.82, and chroma 3.00; while the comparable values of the control of April 27 were 2.75Y, 9.00, and 2.85. These inter-control differences in color attributes exceeded most of the intra-experimental differences reported in the three tables. From this it would appear that the differences in the color of evaporated milk are due not only to processing methods but also, and to a considerable extent, to differences in the raw milk from which the product is produced.

## CONCLUSIONS

1. The heat stability of concentrated milk, relative to that of concentrated milk produced by forewarming at 95° C. for 10 minutes, may be greatly increased by high-temperature forewarming without adding to the color of its evaporated product.

2. Evaporated milks of similar color but made under conditions varying as to temperature and time of forewarming differ greatly in their heat stability.

3. The color of evaporated milk, as affected by forewarming, is not a measure of the heat stability of the concentrate from which it was made.

4. The greater color of evaporated milks of high solids content is not in proportion to the milk solids present in excess of 26 per cent since these milks after dilution with water to 26 per cent solids content have less lightness and greater chroma than do controls of the same composition.

5. The color of evaporated milk depends to a considerable degree on unidentified characteristics of the raw milk from which it is made.

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# AN OUTBREAK OF A MEDICINAL FLAVOR IN MARKET MILK CAUSED BY *AEROBACTER AEROGENES**

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Abnormal flavors of bacterial origin, described as bitter or unclean, have frequently been encountered in milk. While many different organisms will produce this condition in sterile milk in the laboratory apparently fewer types have been involved under actual commercial conditions. It appears that the Escherichia-Aerobacter group has been associated with defects of this general nature more frequently than other organisms (1, 2, 5, 6). Since the group, particularly Aerobacter, is relatively common in raw milk, flavor defects might readily develop in market milk under faulty sanitary and cooling conditions. Furthermore, since the organisms are capable of producing a variety of objectionable flavors (1), modifications of the bitter and unclean flavors might be expected.

The outbreak of a medicinal or chemical flavor herein reported occurred in pasteurized bottled milk at the University Creamery during the warm weather of late spring. Milk retailed to customers was returned to the plant from 1 to 3 days later with the complaint that the flavor was highly objectionable. In most cases all of the milk purchased on that day by each customer was later returned, while in some instances apparently only a part of the milk was affected. Examination of the returned milk confirmed the customers' complaints. The odor was cowy and the flavor suggested chemicals of a disinfectant type. The intensity of the defect was apparently influenced by the stage of development and the conditions under which the milk had been held in the consumers hands. Usually the milk was not noticeably sour, although there was some tendency for the cream layer to show a finely curdled condition.

Examination of unsold bottled milk held over in the plant cooler suggested that the defect was present, in an early stage, in some of this milk. Later, there was also indication that the defect was present to a very limited extent in milk bottled on later dates.

## PROBABLE CAUSES OF THE DEFECT

Since it was evident that not all of the milk in the affected lot was defective, consideration was given to the probability of chlorine sterilizing compounds causing the defect (4). A careful check-up indicated that the condition was not due to the rinsing solution in the lines or equipment since

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some of the last milk to be bottled had been affected. A residue of chlorine rinse in the washed bottles remained a possibility, although tests indicated that a considerable amount was required to produce a chemical flavor of the intensity of the original defect. Furthermore, the flavor produced was not quite typical. It, therefore, seemed doubtful that the abnormal flavor was due to the sterilizing compound. A check-up also indicated that fly sprays were not involved.

After holding the returned milk several hours at room temperature, the medicinal flavor became more intense and was accompanied by a gradual development of acidity which later somewhat masked the original defect. Coagulation occurred rather rapidly accompanied by considerable gas formation.

### REPRODUCTION OF THE DEFECT WITH DEFECTIVE MILK

Inoculations from defective milk into normal pasteurized milk produced the defect to a varied extent in one day at room temperature of approximately 80° F. At lower temperatures, approximately 50° F., the defect developed more slowly but was usually more typical and finally more intense. Accordingly it appeared that the defect was of a bacteriological nature and further studies were made to check this probability and to attempt isolation of the causative organism.

Additional inoculations from defective milk repeatedly reproduced the defect in pasteurized and sterile milk at both temperatures. Furthermore, it was evident that the defect passed through several stages, in most of which the original medicinal flavor could be detected. In the pasteurized milk the development of the defect was apparently influenced by the growth of various types of organisms, while in the sterilized milk the caramelized condition influenced the flavor. Generally, the samples held at the lower temperature developed the most typical condition. Rapid coagulation occurred at room temperature accompanied by gas formation. No coagulation resulted in 6 days at about 50° F. although the flavor defect was very intense. In general the flavor changed from cowy through slightly bitter, to a strong medicinal flavor. It later became intensely unclean. The odor, slightly cowy at first, soon suggested the medicinal and dirty flavors later encountered.

### ISOLATION OF THE CAUSATIVE ORGANISM

Plating of various samples of defective milk, picking of numerous colonies, and examination of cultures resulted in two somewhat similar types of organisms being isolated as the probable cause of the defect. On agar plates one of these produced a large, whitish colony suggesting *Aerobacter aerogenes* while the other gave a somewhat more translucent colony.

Litmus milk cultures from these two organisms at room temperature, while developing only a slight characteristic odor at first, showed a strongly

medicinal flavor in 1 to 2 days which passed through various stages of intensity. While various other organisms were isolated from samples plated at different times none produced the medicinal flavor in litmus milk.

### REPRODUCTION OF THE DEFECT BY PURE CULTURES

After a number of trials it was obvious that both types readily produced the medicinal flavor in sterile and pasteurized milk at room temperature and about 50° F. However, in pasteurzied milk the defect was naturally influenced by the balance of organisms and the conditions under which the milk was held. At room temperature, where changes were rapid, the medicinal flavor developed rapidly but was soon masked by other off flavors and the development of acidity. On the other hand at about 50° F. the defect was typical of the original being preceded by a cowy flavor and odor changing to strong medicinal after 1 to 2 days. In sterile milk the defect was modified by the caramelized condition; at lower temperatures one of the cultures developed a fishy odor.

While the two cultures each produced the defect there was some variation in flavor intensity and other changes caused in milk. The *Aerobacter aerogenes* type culture produced more rapid changes than the translucent type, and in most cases these were more typical of the original. An even more rapid production of the defect was obtained where mixtures of both cultures were inoculated into pasteurized milk. When the inoculated milk was held about 2 hours at room temperature and then in the cooler 1 day a very typical and strong medicinal flavor developed accompanied by a cowy odor similar to that in the original defect. This characteristic was similar to one described by Lockhead (3) where associative action of two organisms produced a more bitter flavor in milk than did either type alone. Later study of the cultures showed that the organisms produced a less intense chemical flavor after being carried artificially for several months.

### IDENTIFICATION

From observations made during the study it appeared that the two types were closely related and suggested Aerobacter species. Morphological and biochemical examinations later verified this. While some minor variations occurred in such characteristics as agar colony, rate of change in litmus milk, and indol formation both were identified as *Aerobacter aerogenes* according to the classification given in Bergey's Manual of Determinative Bacteriology, 1939, which recognizes considerable variation. One type frequently exhibited ropiness which is characteristic of the species. Neither type survived heating at 143° F. for 15 minutes.

### SOURCE OF CONTAMINATION IN PLANT AND CONTROL OF DEFECT

After the isolation of the causative organism investigations were made to detect the source of contamination. Examinations of line run samples

of milk, bottle wash water and rinse water from wash tanks, and washed bottles showed that the organism was occasionally present in relatively large numbers in the wash water in the tanks and in bottles where hand methods were employed. The occurrence of the organisms here would account for some of the characteristics of the original outbreak, such as the presence of the defect in only part of the bottled milk and then to varying extents in different bottles.

A check-up on the bottle washing process indicated that raw milk cans were occasionally hand washed in the tanks during the bottle washing process and these could be a source of *Aerobacter aerogenes* organisms. Furthermore, the use of various part-time individuals for bottle washing, rather than one responsible employee undoubtedly resulted in less efficient cleaning. Evidently, faulty washing procedures had been responsible for the defect. Accordingly, wash and rinse water in the tanks were thereafter changed more frequently and the chlorine rinse was checked more carefully. The washing of milk cans during bottle cleaning operations was avoided as much as possible. As a result of improved washing conditions together with more efficient milk refrigeration the defect was effectively controlled.

## SUMMARY AND CONCLUSIONS

An outbreak of a medicinal flavor in bottled milk was encountered by a small pasteurizing plant during warm weather of late spring and resulted in the return of considerable defective milk. The flavor was very intense and evidently of bacterial origin.

*Aerobacter aerogenes*, isolated from defective samples, readily reproduced the typical defect in pasteurized and sterilized milk and was considered to be responsible for the outbreak.

Hand-washed bottles were found to be the immediate source of the organisms in the milk and improved sanitary procedures in bottle cleaning effectively controlled the defect.

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# FACTORS AFFECTING THE COLOR AND CLARITY OF CASEIN PLASTICS*

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When caseins are made into plastics, they are likely to be cloudy and more or less yellow in color. This has limited casein to the production of plastics with added pigments and dyes to control their appearance. If a highly transparent, colorless plastic from casein were made possible, there are reasons to believe that its commercial possibilities could be greatly extended. With this aim in mind, a study was undertaken of the factors that affect the color and clarity of casein plastics.

## PREPARATION OF THE CASEIN

Rennet casein is now used almost exclusively for making casein plastics. Most of the rennet caseins used in this study were prepared by the suggested (12) method of agitating the skimmilk during coagulation. Rennet extract was added to the skimmilk at 96° F. (35.5° C.) in an amount to produce coagulation in about 15 minutes. The skimmilk was agitated throughout at a moderate rate by means of a mechanical agitator, and as soon as curd particles were evident heating was started. The temperature was raised to 150° F. (65.5° C.) in about 10 to 15 minutes. In the case of Sample 3a, table 1, and certain samples in table 6, where they are suitably identified, the skimmilk was quiescent during coagulation. In these cases the coagulum was broken up by hand stirring, followed by mechanical agitation and gradual heating to 150° F. (65.5° C.). In any case, when the curd had been properly firmed, stirring was discontinued, the curd was allowed to settle, and the whey was withdrawn. Five successive washings with water at 80° F. (26.5° C.) to 90° F. (32.2° C.) were used, each washing consisting of adding the water, thorough stirring, allowing the curd to settle, and withdrawing the water. After the final washing the curd was drained on cheese cloth and finally pressed, with the aid of a sausage press, to reduce the water content as far as possible. The pressed casein was ground by means of a food chopper, and thinly spread on cheese cloth or paper on the shelves in the casein dryer (see figure 1), thermostatically controlled to 115° F. (46.1° C.). Drying was complete in about 2½ hours. Drying conditions as to temperature and time had to be accurately controlled because of their effect on the plastic prepared from the casein.

The moisture content of the casein should be known in its preparation for plasticizing. For this purpose a 10 gram sample of the casein was dried

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under a heat lamp for 6 minutes (7 minutes if the lamp was not prewarmed) and the weight loss was determined. The necessary weighings were made with a Torsion Balance (butter moisture scale). The drying conditions were chosen on the basis of checks against the toluene distillation method for determining moisture. Heat lamps differed somewhat, but it was found that satisfactory checks between lamps and with the toluene distillation method were obtained when each lamp was adjusted to such a height

FIG. 1. Experimental casein dryer. A. Baffle, in 4 parts. The two front parts have been removed to show the fan and the location of the heating units. B. Window sash type of ventilating fan, rated capacity 500 cu. ft. per min. The fan panel is 11¼″ high and spans across the space below the baffle. C. The heating units are located at C, shielded above and below by asbestos board (upper shield removed). Three "Glocoil" units are used; two thermostatically controlled, and one heating continuously. The thermostat is located on the inside near D. D. Air register at each end, adjustable to control the gradual renewal of the air in the dryer. Outside dimensions—78″ long, 44″ high, 33″ wide. Inside dimensions—74″ long, 40″ high, 29″ wide. Wall construction—hollow, ¼″ veneer outside, ½″ prestwood inside. Shelves—9 shelves, 29″×6¼″, wooden frame covered with ½″ square mesh, galvanized iron screen; free space between shelves, 2″; free space at ends of shelves and baffle, 6″.

as to produce a temperature of 230° F. (110° C.) in the position of the sample in 10 minutes as measured by a thermocouple. This method is rapid, and was entirely satisfactory for the purpose.

### DETERMINING THE FAT CONTENT OF CASEIN

The fat content of casein is one of the factors that affect the color and clarity of the plastic. Therefore, in the case of samples where this factor was of special interest the fat content was determined.

The fat is apparently occluded by the casein in such a manner that its extraction is not easily accomplished. Direct extraction with ether has been reported to yield low results (2) that are variable with the mesh size of the casein (11), and even when the casein is finely ground to 100 mesh size, extraction must be prolonged to 48 hours (11). The Roese-Gottlieb extraction, relying on the water and ammonia to dissolve the casein, was tried in the present study, but was unsatisfactory. The results were low and variable, apparently because of incomplete solution of the casein and gel formation during extraction. Delorme (4) and Fouassier (5) have employed digestion with hot concentrated hydrochloric acid preparatory to wet extraction, and Bray and Major (2) have concluded that no ether soluble hydrolytic products from the casein become involved in the fat determination. This type of procedure was adopted in the present study.

The fat tests were made with the use of the Roese-Gottlieb extraction as conducted by the Mojonnier procedure and equipment, except that ammonia was omitted and hydrochloric acid digestion of the sample was used in its stead. Two-gram samples of casein were used, and these were digested with 6 ml. of diluted hydrochloric acid (1 volume of water to 2 volumes of concentrated hydrochloric acid) in a boiling water bath for forty minutes. This treatment effected complete solution of the casein except in those cases where excessive heat treatment was involved in the history of the casein. In such cases the digestion had to be prolonged. After digestion with acid, water was added to bring the volume of the liquid to the proper level in the extraction flask (volume about 12 ml.), and the extraction was made with 10 ml. alcohol, 25 ml. ether, and 25 ml. petroleum ether in the customary manner. In the second extraction 5 ml. alcohol, 15 ml. ether, and 15 ml. petroleum ether were used.

## MAKING THE CASEIN PLASTIC

The conversion of rennet casein into a plastic requires the application of heat and pressure to the moistened casein. If the individual casein granules are to lose their identity so that maximum clarity (and strength) may be attained, it is necessary to have some mixing action such as may be produced by flow under pressure. The desired slabs of casein plastic for color and clarity observations could therefore not be made by merely compressing the moistened rennet casein under heat and pressure. To involve flow the test strips or sheets were prepared by extruding the casein through a slit into a die of the desired dimensions. The equipment which was designed and built for this purpose is illustrated in figure 2, and the exact procedure is given in the following steps:

(1) The rennet casein was moistened to a moisture content of about 27.5 per cent, thoroughly mixed, and allowed to stand for at least 30 minutes before applying the next step. A 20-gram charge of casein was employed

for each test strip, and with a normal moisture content of 8 per cent, the required water addition was 5.4 ml.

(2) The moistened casein was placed into the cylinder of the assembled equipment. The piston was put into position, and free flowing steam was applied in the jacket of the cylinder. At least 5 minutes were allowed for the penetration of the heat through the casein and the die. If the next step was applied too soon, the lack of heat penetration resulted in incomplete plasticizing of the casein along the middle of the test strip.

(3) Pressure was applied to the piston by means of a Carver laboratory press. Extrusion of the casein took place quite readily at a gauge reading of 6000 lbs. pressure, and this pressure was maintained. Extrusion could easily be recognized by the tendency of the pressure to ebb, and complete filling of the die was evident when this tendency ceased.

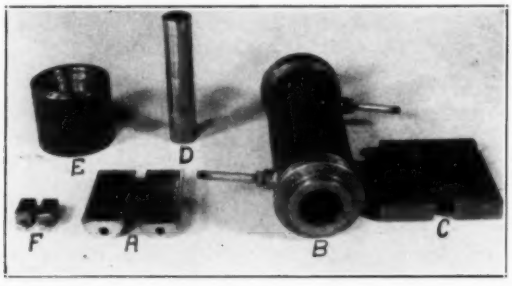


FIG. 2. Equipment for casting casein plastic test strip. A. The two halves of the die, length $4^{33}/_{64}$", chromium plated to minimize adhesion of the plastic. The left piece is flat; the right piece has a channel milled in it, $1\frac{1}{2}$" wide, $\frac{1}{8}$" deep, except that within $\frac{3}{4}$" from the top the channel gradually becomes more shallow down to 0.012" for the final $\frac{1}{4}$". B. Jacketed cylinder, length $11\frac{1}{2}$", and $1\frac{1}{2}$" in diameter except that $4\frac{1}{2}$" from the bottom the diameter is increased to 2", leaving a shoulder against which the inserted die seats. From this shoulder down the diameter increases very gradually to accommodate the slightly tapered die assembly. C. Base into which the cylinder is securely threaded after the die has been placed into the lower opening of B. The hole in the center of C and a groove on the under side permit the escape of air and of any surplus plastic after the die is filled. D. Piston, upper half slightly smaller in diameter. E. Special base for removing the die and piston. After the test strip has been cast, B is unscrewed from C, B is then placed on E and pressure on the piston releases A, which is removed. Further pressure on the piston then forces it through the cylinder to free it. F. The pegs of F are inserted into the holes of A so that a wedge may be applied to force the die halves apart and the test strip may be removed.

(4) Cold water was then allowed to flow through the jacket to cool the plastic and also for convenience in handling the cylinder. After cooling, the base was unscrewed, the die and piston were forced through and free from the cylinder, and the test strip of plastic was removed from the die. The plastic strip, which is tough and has only limited pliability at this stage,

will become curved on pulling it free from the die. Flatness was restored with pressure by hand against a plane surface.

(5) The plastic strip was suspended for air drying, using spring type clothes pins strung on a wire. By allowing the drying to proceed uniformly from both sides of the strip warping was avoided. There is some contraction on drying; the strips were cast to a thickness of 3.175 mm. ($\frac{1}{8}$ inch) and were about 3 mm. thick after drying.

(6) The chromium plated die surfaces were purposely left unpolished in the belief that the plastic would be easier to remove. As a result the plastic strips did not have a highly glossy surface. Gloss was imparted by dipping them into a solution consisting of 90 volumes of glacial acetic acid and 10 volumes of 30 per cent formaldehyde, followed by air drying. This treatment could be applied before the drying as in Step 5 or as a subsequent operation.

## CLARITY AND COLOR TESTS ON PLASTICS

The clarity of the glossy plastic strips was measured by means of a KWSZ photometer, using a 520 mμ filter. A piece of photometer cell glass, 2.5 mm. thick, was used as the standard taken as 100 per cent (light transmission). The plastic strips were somewhat thicker than the glass and no correction was attempted for this factor. The highest degree of clarity attained with any of the casein plastics was 91.7 per cent.

Color measurements were made with a Lovibond tintometer against a white background supplied by magnesium carbonate blocks.

## PREPARATION OF A TRANSPARENT PLASTIC AND THE EFFECT OF VARIOUS ADDITIONS

To study the factors that contribute to the color and opacity of the plastic it was desirable to develop a casein which would produce a highly transparent, colorless plastic. By means of known additions to such casein the effect on color and clarity could then be observed.

Early in the study while seeking to dry casein without the application of heat it was found that extraction of the moist casein with warm alcohol or acetone resulted in a clear plastic. Bartels (1), 1916 and 1921, patented the treatment of casein with alcohol and mixtures of alcohol and benzene to remove the last traces of fat to produce a transparent horn-like material. He applied his extraction to dry commercial casein at 80° to 90° C. In a recent foreign patent, Langdecker (7), 1937, patented the use of methyl alcohol and mixtures of methyl and ethyl alcohol as solvents for the extraction of fat from casein to produce a transparent plastic. Langdecker stated that in extraction of the commercial casein with ethyl alcohol a dark red plastic resulted, but that this did not occur when methyl alcohol or mixtures of methyl and ethyl alcohol were used. This defect was not encountered in the present study with ethyl alcohol used as indicated.

In the present investigation the alcohol or acetone extraction was applied at 140° to 150° F. (60° to 65.5° C.) to moist casein as it came from the press, the alcohol or acetone acting as a drying agent as well as an extractant. Enough of the solvent was added to attain a concentration of 70 to 80 per cent taking into consideration the 55 to 60 per cent moisture in the pressed casein. The moist casein appeared to lend itself more favorably to extraction than the dry casein. Hot extraction was found advisable; extracts so made, on cooling, became turbid and a precipitate formed. The color of this precipitate indicated that it contained most of the riboflavin obtained by the hot extraction. Extraction temperatures higher than those stated tended to discolor the casein to some extent and made it more difficult to plasticize.

The alcohol or acetone solution obtained by extracting casein contained fatty and non-fatty material including riboflavin. Separation of the fatty and non-fatty constituents was accomplished by evaporating off the solvent under vacuum, grinding the yellow, waxy residue with sand, and extracting with alcohol, ether and petroleum ether mixed in the proportions of 10, 25 and 25 ml. as used in the Roese-Gottlieb extraction. Ether alone tended to produce a gel condition in the residue so that extraction was unsatisfactory.

The fatty material, recovered by evaporating the solvent, contained phospholipids as shown by re-solution with acetone. In one such test 18.2 per cent of the fatty material failed to dissolve in the acetone, and was assumed to be chiefly phospholipid.

The non-fatty material was recovered from the sand, after the extraction of the fatty material, by re-dissolving it from the sand with warm 70 to 80 per cent alcohol and filtering through a Büchner filter. The solid material recovered from this solution was greenish-yellow in color, presumably because of the riboflavin contained in it. The presence of riboflavin was further indicated by fluorescence when the non-fatty material was observed under ultra-violet light.

Quantitative observations were made in connection with the extraction of one low-fat casein. Alcoholic extraction removed 1.6 per cent of the casein, consisting of 0.3 per cent fatty and 1.3 per cent non-fatty material.

It was concluded that the fatty material consisted of true fats and fat-like compounds, chiefly phospholipids, and that the non-fatty material was chiefly protein and contained riboflavin. No further identification was attempted. The presence of an alcohol soluble protein in casein was demonstrated by Osborne and Wakeman (8), who extracted casein with 70 to 80 per cent alcohol and reported the dissolved material as a new protein in milk. Funk (6) extracted a casein, which had been purified by washing with alcohol and ether, with boiling alcohol and obtained a "fat soluble substance." Presumably this was a fatty material, and apparently hot extraction with alcohol is required to remove it from casein.

TABLE 1

*The effect of extractable materials in casein on the color and clarity of casein plastic*

| Sample No. | Description of casein | Fat content of casein* | Color of plastic Lovibond units | | | Light transmission of plastic† |
|---|---|---|---|---|---|---|
| | | | Yellow | Red | Blue | |
| | | *per cent* | | | | *per cent* |
| 1a | Control, rennet casein, not extracted | ..... | 2.1 | 0.9 | 0.2 | 23.2 |
| 1b | No. 1a, 1 alcohol extraction at 140°–150° F. | ..... | 1.0 | 0.4 | 0.0 | 78.0 |
| 1c | " , 2 " " " " " | ..... | 0.9 | 0.3 | 0.0 | 90.3 |
| 1d | " , 3 " " " " " | ..... | 0.8 | 0.3 | 0.0 | 91.7 |
| 2a | Control, rennet casein, not extracted | ..... | 2.7 | 0.3 | 0.2 | 22.3 |
| 2b | No. 2a, 1 alcohol extraction at 140°–150° F. | ..... | 1.0 | 0.3 | 0.0 | 68.9 |
| 2c | No. 2a, 2 " " " " " | ..... | 1.0 | 0.2 | 0.0 | 89.1 |
| 3a | Control, rennet casein, not extracted | ..... | 3.1 | 1.0 | 0.1 | 16.2 |
| 3b | No. 3a, 2 alcohol extractions at 140–150° F. and cold alcohol rinse | ..... | 1.5 | 0.4 | 0.0 | 81.4 |
| 3c | No. 3b, with further extraction by alcohol plus $H_2O_2$ | ..... | 0.7 | 0.1 | 0.0 | 89.2 |
| 3d | No. 3b, with further extraction by dilute HCl at pH 5 | ..... | 0.7 | 0.1 | 0.0 | 87.1 |
| 4a | Control, acid casein,‡ not extracted | ..... | 3.4 | 1.2 | 0.5 | 10.7 |
| 4b | No. 4a, 1 extraction with acetone at 140–150° F. | ..... | 1.4 | 0.6 | 0.0 | 69.4 |
| 4c | No. 4a, 1 " " alcohol at 140–150° F. | ..... | 0.9 | 0.3 | 0.0 | 78.5 |
| 5a | Control, rennet casein, alcohol extracted | 0 | 0.7 | 0.2 | 0.0 | 89.8 |
| 5b | No. 5a + 0.3% fatty material | 0.3 | 2.2 | 0.9 | 0.0 | 38.8 |
| 6a | Control, rennet casein, alcohol extracted | 0.12§ | 1.6 | 0.4 | 0.0 | 89.3 |
| 6b | No. 6a + 0.38% butter oil | 0.5 | 2.8 | 1.2 | 0.0 | 18.8 |
| 6c | No. 6a + 0.88% " " | 1.0 | 3.8 | 1.4 | 0.0 | 6.2 |
| 6d | No. 6a + 1.38% " " | 1.5 | 3.8 | 1.4 | 0.0 | 5.0 |
| 6e | No. 6a + 10% non-fatty material | ..... | 2.6 | 0.9 | 0.0 | 83.4 |
| 7a | Control, rennet casein, alcohol extracted | ..... | 0.8 | 0.2 | 0.0 | 86.9 |
| 7b | No. 7a + 5% non-fatty material | ..... | 1.4 | 0.7 | 0.0 | 86.4 |

* Fat content on basis of moisture-free casein.

† Light transmission is expressed as per cent throughout this study as measured by photoelectric comparisons with a piece of photometer cell glass, 2.5 mm. thick, taken as 100 per cent.

‡ The acid casein in samples 4a–4c were prepared for plasticizing by moistening the casein with an 8 per cent solution of calcium acetate instead of the water customarily used for the rennet caseins.

§ Extraction incomplete.

The extracted caseins were used to prepare plastic test strips. Further test strips were prepared from the extracted caseins with the several fractions of the extracted material returned to the casein. Table 1 shows the results obtained. It was found that a relatively color-free and transparent plastic could be made from casein that had been extracted with alcohol (undenatured) or acetone. Alcohol was employed for most extractions because it was more readily available. The desired improvement was attained most readily with well washed casein of good quality such as Sample 1a. Sample 3a was a coarsely cut, poorly washed casein, and two alcohol extractions plus a cold alcohol rinse still left the color higher than that attained by one alcohol extraction (Sample 1b) of the better casein.

The return of the fatty material to the casein increased both the color and the opacity of the plastic. The addition of relatively large amounts of the non-fatty material caused considerable increase in color without, however, having much effect on clarity. Since the additions of 5 and 10 per cent non-fatty material (Samples 7b and 6e) were far greater than the normal content of such material in casein, it appears to be of only minor importance in determining color and clarity. These large additions were made to determine the direction of the effect after small additions had failed to produce readily measurable changes.

The fact that the fatty material, particularly the true fats, cause marked increases in opacity is shown by Samples 6a to 6d, table 1. The butter oil additions in these samples were derived from winter butter that had been colored with carotene to resemble the natural color of summer butter. The color increases in the test strips, therefore, include the effect of carotene. In a separate test it was found that 6 micrograms of carotene to the 20-gram portion of casein used in making a test strip, caused the yellow color to increase by 0.5 Lovibond unit. In other tests it was shown that phospholipids have less effect on opacity than do similar amounts of true fats. Using an alcohol extracted casein which produced a plastic with 67.4 per cent light transmission, the addition of 0.5 per cent fat to the casein reduced light transmission to 14.7 per cent, while 0.5 per cent phospholipids reduced it only to 28.2 per cent. The effect of phospholipids on color also was less than that of the fat.

## RIBOFLAVIN

The presence of riboflavin in the non-fatty portion of the alcoholic extract from casein has already been noted. Riboflavin may, however, be involved in the color of the plastic to a greater degree if the casein is poorly washed. The riboflavin content of skim milk has been given (10) as 162.5 micrograms per 100 ml. There is some basis for assuming that 50 per cent of the riboflavin may remain with the curd until it is washed, and even then from 10 to 20 per cent of the original content in skim milk may remain with the curd according to the thoroughness of washing. Accordingly, additions

TABLE 2

*The effect of riboflavin on the color of casein plastics*

| No. | Description of casein | Color of plastic Lovibond units | | |
|---|---|---|---|---|
| | | Yellow | Red | Blue |
| 8a | Control, rennet casein | 1.8 | 0.7 | 0.0 |
| 8b | No. 15a + 114 micrograms riboflavin* | 3.5 | 0.9 | 0.0 |
| 8c | " " + 227 " " * | 5.1 | 0.9 | 0.0 |
| 9a | Control, rennet casein | 1.5 | 0.6 | 0.0 |
| 9b | No. 16a + 114 micrograms riboflavin* | 3.1 | 0.9 | 0.0 |
| 9c | " " + 227 " " * | 5.2 | 0.9 | 0.0 |

* Added to 20 grams air-dry casein, and assumed to represent approximately 10 and 20 per cent, respectively, of the original content in the skim milk.

were made to casein as shown in table 2. The additions were made by allowing the air dry casein to absorb an alcoholic solution of the riboflavin and then drying. These additions caused marked increases in the yellow color of the plastic. The 114 microgram addition closely duplicated the color that had been observed in plastics made from poorly washed casein.

### ALUM ADDITIONS

The addition of about 2 per cent alum to casein has been suggested by Christensen (3) as a means of making the resulting plastic harder and more suitable for turning on automatic machines. The effect of such an addition was studied as shown in table 3. The effect of hardening the plastic in a formaldehyde bath was also observed, and in one sample, glycerol was included because it is frequently used as a plasticizer. It was found that alum increases opacity quite markedly and causes some increase in yellow color. Formaldehyde curing further increased the opacity.

### THE FAT CONTENT OF THE CASEIN

The marked effect of the fat content of the casein on the clarity of the plastic is definitely shown in table 1. As a further study of this factor,

TABLE 3

*Plastic test strips from casein with alum added; formaldehyde curing*

| No. | Description of casein | Color of plastic, Lovibond units | | | Light transmission of plastic |
|---|---|---|---|---|---|
| | | Yellow | Red | Blue | |
| | | | | | *per cent* |
| 10a | Control, rennet casein, alcohol extracted | 1.0 | 0.5 | 0.0 | 87.8 |
| 10b | No. 17a + 2% aluminum-potassium sulfate | 1.5 | 0.5 | 0.0 | 45.3 |
| 10c | No. 17b, plastic cured in formaldehyde | 1.5 | 0.5 | 0.0 | 33.3 |
| 11a | Control, rennet casein, alcohol washed, glycerol added | 1.0 | 0.4 | 0.0 | 77.4 |
| 11b | No. 18a + 2% aluminum-potassium sulfate | 1.7 | 0.5 | 0.0 | 39.2 |
| 11c | No. 17b, plastic cured in formaldehyde | 1.7 | 0.5 | 0.0 | 28.0 |

TABLE 4

*The effect of the fat content of casein on the color and clarity of casein plastic*

| Sample No. | Description of casein | Fat content of casein | Color of plastic, Lovibond units | | | Light transmission of plastic |
|---|---|---|---|---|---|---|
| | | | Yellow | Red | Blue | |
| | | *per cent* | | | | |
| 12 | From skimmilk testing 0.01 % fat | 0.52 | 2.0 | 0.9 | 0.1 | 35.1 |
| 13 | " " " 0.015 " " | 0.53 | 2.2 | 0.9 | 0.0 | 31.0 |
| 14 | " " " 0.02 " " | 0.58 | 2.2 | 0.9 | 0.1 | 30.5 |
| 15 | " " " 0.025 " " | 0.61 | 2.2 | 0.9 | 0.1 | 27.0 |
| 16 | " " " 0.03 " " | 0.64 | 2.2 | 0.9 | 0.1 | 21.3 |
| 17 | " " " 0.035 " " | 0.66 | 2.2 | 0.9 | 0.1 | 15.2 |
| 18 | " " " 0.04 " " | 0.78 | 2.2 | 0.9 | 0.1 | 14.4 |
| 16a | No. 16 + Fat to a total fat content of | 0.9 | 2.9 | 1.1 | 0.0 | 13.7 |
| 16b | No. 16 + " " " " " " " | 1.0 | 2.9 | 1.1 | 0.0 | 13.6 |
| 13a | No. 13 + " " " " " " " | 1.1 | 2.9 | 1.1 | 0.0 | 9.7 |
| 13b | No. 13 + " " " " " " " | 1.2 | 3.6 | 1.1 | 0.0 | 6.7 |
| 18a | No. 18 + " " " " " " " | 1.4 | 3.7 | 1.1 | 0.0 | 6.3 |
| 18b | No. 18 + " " " " " " " | 1.9 | 4.3 | 1.1 | 0.0 | 4.6 |
| 19 | From skimmilk | 0.39 | 2.5 | 0.9 | 0.0 | 33.1 |
| 20 | From 3 parts skimmilk & 1 part buttermilk | 2.47 | 3.9 | 1.4 | 0.1 | 6.9 |
| 21 | " 2 " " & 1 " " | 4.6 | 4.2 | 1.4 | 0.1 | 2.7 |
| 22 | Nos. 20 & 21 mixed equal parts, dried at 165° F. | (3.85)* | 6.4 | 2.4 | 0.1 | 3.0 |

* As computed from known mixture.

caseins and plastics were prepared from skim milks ranging in fat content from 0.01 to 0.04 per cent as measured by the Babcock test. Still higher increases in fat content were produced by allowing the air dry casein to absorb an ether solution of the weighed amount of fat and then allowing the ether to evaporate. The fat content was also increased by the admixture of buttermilk in the skim milk. Such admixture is a possibility in commercial practice where casein is made at a creamery. The plastics made from these caseins showed a decided increase in opacity and some increase in color with increases in fat content, as seen in table 4.

The fatty material originating from buttermilk apparently was not quite as effective in causing opacity as true fats. This is indicated by Samples 13b and 20; in Sample 13b a fat content of 1.2 per cent decreased light transmission in the plastic to 6.7, but in Sample 20 2.47 per cent fat, with the fatty material derived chiefly from buttermilk, light transmission was 6.9 per cent. This is probably due to the fact that a considerable portion of the fatty material in buttermilk consists of phospholipids, which have already been shown to be somewhat less effective than true fats in causing opacity in the casein plastic.

It should be noted, incidentally, that the inclusion of buttermilk delayed rennet coagulation and made it difficult to obtain a firm curd in making the casein. Sample 22 indicates the detrimental effect of using a high temperature in drying the casein, a factor which will be more fully treated later.

### PASTEURIZING TEMPERATURE

Where the skim milk is pasteurized before it is made into casein, the color and clarity of the final plastic might well be affected by the heat treatment due to direct effects on the casein, coagulation of proteins normally lost in the whey, precipitation of calcium phosphate, or slight caramelization. Such effects might even be involved to some degree where the casein is made from raw skim milk due to the use of temperatures up to 150° F. (65.5° C.) in firming the curd after coagulation with rennet. These factors were studied and the results are given in table 5.

The color and opacity of the plastics increase quite markedly as the pasteurizing temperature of the skimmilk is increased. The increase in opacity is apparently due largely to the greater retention of fat in the casein where higher pasteurizing temperatures are used. The inclusion of coagulated whey proteins may be a slight factor as is indicated by Samples 30 and 34 compared with their respective control samples. The coagulated whey proteins were prepared from the rennet whey obtained from an amount of skim milk equal to that used later in making the casein. Coagulation of the whey proteins was accomplished by heating the rennet whey to 170° F. (76.7° C.) and acidifying to pH 4.8 (as measured at room temperature). Samples 29 and 32 were included to imitate the effects of local high temperatures or momentary high temperatures in direct steam pasteurization.

TABLE 5

*Effect of pasteurizing temperature, acidity, drying temperature and coagulated whey proteins on color and clarity of casein plastic*

| Sample No. | Description of casein | Fat content of casein | Color of plastic, Lovibond units | | | Light transmission of plastic |
|---|---|---|---|---|---|---|
| | | | Yellow | Red | Blue | |
| | | *per cent* | | | | *per cent* |
| 23 | Control from raw skimmilk | 0.505 | 3.0 | 1.6 | 0.7 | 29.9 |
| 24 | From skimmilk heated to 145° F. 30 min. | 0.538 | 3.0 | 1.6 | 0.5 | 27.9 |
| 25 | " " " " 150° F. " " | 0.633 | 3.1 | 1.6 | 0.5 | 29.9 |
| 26 | " " " " 160° F. " " | 0.625 | 5.0 | 2.3 | 0.5 | 21.5 |
| 27 | " " " " 170° F. " " | 0.712 | 6.4 | 2.3 | 0.6 | 16.1 |
| 28 | " " " " 180° F. " " | 0.871 | 6.7 | 2.3 | 0.6 | 12.4 |
| 29 | ¼ of skimmilk " " 190° F. by direct steam | 0.494* | 3.3 | 1.6 | 0.5 | 24.0 |
| 30 | From raw skimmilk plus ⅓ of the coagulated whey proteins | 0.55 | 3.7 | 1.6 | 0.6 | 25.0 |
| 31 | Control, from raw skimmilk | ..... | 2.5 | 1.0 | 0.0 | 21.0 |
| 32 | ¼ of skimmilk heated to 200° F., direct steam | ..... | 2.9 | 1.0 | 0.0 | 7.0 |
| 33 | Control, from raw skimmilk | 0.595 | 2.4 | 1.0 | 0.0 | 24.3 |
| 34 | From raw skimmilk + ⅓ of the coagulated whey proteins | 0.688 | 2.8 | 1.0 | 0.0 | 19.9 |
| 35 | Control, from raw skimmilk, acidity 0.165% | 0.525 | 2.1 | 0.9 | 0.0 | 38.8 |
| 36 | From skimmilk, acidity 0.18% | 0.504 | 2.1 | 0.9 | 0.0 | 39.8 |
| 37 | " " " 0.19% | 0.56 | 2.1 | 0.9 | 0.0 | 36.1 |
| 38 | " " " 0.207% | 0.55 | 2.1 | 1.0 | 0.0 | 30.0 |
| 39 | " " " 0.27% | 0.62 | 2.6 | 1.3 | 0.5† | 18.0 |
| 40 | " " " 0.35% | 0.49 | 2.3 | 0.9 | 0.0 | 24.8 |
| 41 | " " " 0.42% | 0.47 | 4.5 | 1.3 | 0.0 | 11.4 |
| 42 | From raw skimmilk, dried at 115° F. | ..... | 1.6 | 0.7 | 0.0 | 43.6 |
| 42a | No. 42 dried at 165° F. | ..... | 3.1 | 1.0 | 0.1 | 37.0 |
| 43 | From skimmilk heated to 160° F., dried at 115° F. | ..... | 6.1 | 2.8 | 1.0 | 4.4 |
| 43a | No. 43 dried at 165° F. | ..... | 9.1 | 3.3 | 1.0 | 4.7 |

* Sample not in complete solution for fat determination.

† The increased blue is probably due to the effect of the acid on a poorly tinned container with resulting solution of the metal in the skimmilk.

### ACIDITY OF THE SKIM MILK

Since pasteurization is undertaken only as a means of preventing souring and other deterioration of the skim milk where the making of rennet casein from it needs to be delayed, the effect of acidity is directly relevant. This factor was studied experimentally by allowing raw skim milk to stand at 90° F. (32.2° C.) and taking portions for making rennet casein at various stages in the acid development as shown for Samples 35 to 39, table 5. Samples 40 and 41 were from another lot of skim milk similarly held but with occasional stirring during the souring. This had the effect of causing a fatty scum to collect at the surface when the acidity had reached 0.30 to 0.35 per cent, expressed as lactic acid. The removal of this scum caused a lower fat content in the casein. All of the caseins in this series were made with constant agitation during coagulation with the rennet and during subsequent heating.

Increased acidity accelerated the coagulation and caused the curd particles to collect into larger clumps. This makes washing more difficult and, as a result, there is an increase in the color of the plastic. The clumping of the curd also causes a slightly greater retention of fat, which contributes to color and opacity. However, apart from these effects, increased acidity seems to cause an increase in opacity. Sample 40 was apparently washed as thoroughly as Samples 35–38 as indicated by color, and its fat content was lower, yet it produced a more opaque plastic. The rennet casein prepared from skim milk with a high acidity undoubtedly has a lower ash content, tending to approach acid casein. An acid casein mixed with rennet casein was shown, by actual trial, to produce a cloudy plastic.

Neutralization of high acid skimmilk with sodium carbonate or calcium hydroxide did not improve the clarity of the plastic. Neutralization with tri-sodium phosphate caused some improvement in clarity, apparently because of less fat retention in the casein. Rennet coagulation is made abnormal and the curd less firm so that less fat is retained. In any case, the amount of this salt required for neutralization is excessive, and the procedure is impractical.

### CASEIN DRYING TEMPERATURE

For the drying of rennet casein a temperature of about 110° F. has been recommended, while for acid casein higher temperatures such as 145° F. are commonly used. The importance of a low temperature in drying rennet casein has been confirmed in this study. As is shown by Sample 42a and 43a, table 5, elevated temperatures cause increases in color and some increase in opacity. Even slightly elevated temperatures are detrimental when drying is prolonged. For example, a casein dried at 125° F. (51.7° C.) for 2¼ hours produced a plastic with 32.7 per cent light transmission, but on 2 hours additional drying of the casein, light transmission of the plastic was 29.1 per cent.

TABLE 6

*The effect of agitation during coagulation on the color and clarity of casein plastics*

| Sample No. | Description of casein | Coagulation and heating time | | Fat content of casein | Color of plastic, Lovibond units | | | Light transmission of plastic |
|---|---|---|---|---|---|---|---|---|
| | | Coagulation* | Heating† | | Yellow | Red | Blue | |
| | | *min.* | *min.* | *per cent* | | | | *per cent* |
| 44 | No agitation during coagulation | 24 | 37 | 0.53 | 2.6 | 0.9 | 0.0 | 22.7 |
| 45 | Agitation " " | 12 | 27 | 0.43 | 2.2 | 0.5 | 0.0 | 36.9 |
| 46 | $CaCl_2$ added, no agitation during coagulation | 15 | 33 | 0.54 | 2.5 | 0.8 | 0.0 | 25.2 |
| 47 | " " agitation " " | 8 | 25 | 0.41 | 1.9 | 0.5 | 0.0 | 29.5 |
| 48 | No agitation during coagulation | ..... | ..... | 0.59 | 2.4 | 0.8 | 0.0 | 23.3 |
| 49 | Agitation " " | ..... | ..... | 0.49 | 1.8 | 0.7 | 0.0 | 34.0 |
| 50 | No agitation during coagulation | 20 | 29 | 0.60 | 2.4 | 1.0 | 0.0 | 24.3 |
| 51 | Agitation " " | 13 | 24 | 0.49 | 2.3 | 1.0 | 0.0 | 35.2 |
| 52 | Part of skimmilk heated to 190° F., no agitation | ..... | ..... | 0.62 | 2.8 | 1.0 | 0.0 | 29.4 |
| 53 | " " " " " " ", agitation | 15 | 23 | 0.52 | 2.7 | 1.0 | 0.0 | 33.8 |

* Coagulation time for non-agitated samples means time from setting to cutting of curd; for agitated samples, from setting to first visible curd particles, when heating was started.

† Heating time expressed as total time from setting until 150° F. was reached.

The relation of sugars to color development in milk products has been pointed out by Ramsey, Tracy and Ruehe (9). That the presence of lactose causes pronounced darkening of color in drying cheese for moisture tests is well known. In harmony with this, it was found that a coarsely cut, poorly washed casein took on a decided brown color on drying at elevated temperatures, or on greatly prolonged drying at the usual drying temperature, whereas a well washed casein remained relatively white.

In connection with drying practices, the effects of putrefactive changes in casein due to delayed drying were studied. The wet casein was allowed to stand until a putrefactive odor developed, but plastics made from these caseins showed no significant change in color and clarity. However, it was found that a plastic might result with small gas holes in it, due to abundant gassy fermentation during the holding of the moistened casein preparatory to extrusion.

### AGITATION DURING COAGULATION IN MAKING RENNET CASEIN

The results of this study indicate quite clearly that for minimum color and opacity in the ultimate plastic, the rennet casein must be so made as to contain a minimum of fat and whey solids. The suggested method (12) of agitating the skim milk during coagulation with rennet and starting the heating as soon as curd particles are evident was studied in comparison with quiescent coagulation as shown in table 6. In all cases agitation during coagulation produced a lower fat content in the casein and the resulting plastic had less color and greater clarity.

In the agitation method the size of the curd particles can be controlled by the vigor of agitation and by the rate of heating. Slow heating yields fine curd particles and rapid heating produces coarser curd clumps. The curd clumps are relatively porous and spongy so that they can be washed more thoroughly than is true for curd particles of similar size produced by quiescent coagulation.

The agitation method requires somewhat less time as is shown in table 6. Less attention is required since the heat is turned on as soon as visible curd particles are seen, and repeated observations to note the firmness of the coagulum are eliminated. However, there is a slight loss in yield. The small scale operations used in this study did not permit accurate determination of this loss; it appeared to be approximately 0.1 pound of dry casein per 100 pounds of skim milk. Most of this loss is probably due to actual loss of casein; to some degree it is due to the lower fat content in the casein and more complete removal of whey solids.

### EXTRANEOUS MATTER

Extraneous matter in the skim milk tends to be occluded by the curd. It obviously may be a source of color and opacity in the plastic. Observa-

tions made in this study indicate that this possibility should not be overlooked. Rust from iron pipes and vats was found to be very detrimental to color and clarity.

## SUMMARY

1. Equipment is described and procedures are given for converting casein into plastic test strips that are suitable for accurate color and clarity measurements.

2. By extracting a rennet casein of good quality with alcohol or acetone at 140 to 150° F. it is possible to make a plastic from it with very low color and high transparency.

3. Fat contained in the casein is largely responsible for the opacity of the plastic. Fat also contributes to the color.

4. The inclusion of buttermilk in making casein is detrimental to the color and clarity of the plastic due to the increased fat content contributed by the buttermilk.

5. Riboflavin held by the casein is largely responsible for the yellow color of the plastic, especially if the casein was poorly washed.

6. Alum additions in making the plastic increase its opacity and accentuate its color. Formaldehyde curing of the plastic causes some increase in opacity.

7. Excessive heating of the skim milk from which the casein is made increases both the color and the opacity of the plastic.

8. High acidity in the skim milk from which the casein is made is detrimental to the color and clarity of the plastic, due to the poorer washing qualities of the casein, greater fat retention by the casein, and, in part, probably due to the lower ash content of the casein.

9. The incorporation of coagulated whey proteins increased the opacity of the plastic.

10. Prolonged drying or exposure of the casein to excessive temperatures are detrimental to the color and clarity of the plastic, especially so if the casein was poorly washed.

11. Incipient putrefaction of the casein prior to drying was not detrimental to the color or clarity of the plastic, but in some cases led to gas holes in the plastic.

12. The method of making rennet casein with agitation applied during the coagulation produced some improvement in the color and clarity of the plastic due to the better washing qualities of the casein and its lower fat content. The time for making the casein is reduced by this method, but there is a slight loss in yield.

13. Extraneous matter may be a source of color and opacity in the plastic.

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# THE INFLUENCE OF SEVERAL FACTORS UPON THE FLAVOR OF FROZEN SWEET CREAM[1]

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Inasmuch as the seasonal periods of maximum production and maximum utilization of butterfat do not coincide, butterfat must be stored in periods of high production for use when the demand exceeds the supply. Frozen cream offers one means of storing butterfat. However, the storage of frozen cream is not without its problems, one of which is the development of oxidized flavor.

Macroscopic examination of cream produced during the winter months as contrasted to that produced during the summer months often shows the winter cream to be decidedly lacking in color, whereas, the summer cream has a high-yellow color. As pointed out by Anderson (1) Anderson, Hardenbergh and Wilson (2) and Garrett, Tucker and Button (5) this high color apparently is associated closely with good flavor in milk. Likewise, milk having a high color appears to be less susceptible to the development of oxidized flavor than milk lacking yellow color. If carotenoids are one of the flavor-stabilizing factors, then summer cream would seem to withstand storage better than winter cream. However, some plant operators have occasion to store sweet cream at other seasons of the year than during the summer months when butterfat production is usually at the highest.

Since homogenization stabilizes the flavor of milk against copper-induced oxidation, as shown by Tracy, Ramsey and Ruehe (10) and later substantiated by Thurston, Brown and Dustman (9), Ross (8) and Trout and Gould (11), homogenization of high-fat cream would seem to be beneficial in stabilizing the flavor of the cream upon storage regardless of the season during which it was produced. In several trials, using various temperatures of pasteurization and treatments with copper, McFarland and Burgwald (7) observed that homogenization was effective in preventing or retarding the development of oxidized flavor in frozen cream.

The time and temperature of pasteurizing cream intended for frozen storage has varied widely. The findings of Gould and Sommer (6), showing that temperatures around 175° F. produce sulfhydryl compounds which are responsible for the cooked flavor and the retarded oxidation of the fatty constituents of milk, have encouraged higher-temperature pasteurization of cream. In recent work, Dahle, Lawhorn and Barnhart (3) showed that a flash temperature of 170° F. furnished flavor protection in creams having a copper content between 0.75 and 1.12 ppm. Dahle (4) has made

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a complete review of the subject of frozen cream. An extensive review in this paper therefore would seem unnecessary.

## SCOPE OF THE INVESTIGATION

In February, 1940 extensive studies were undertaken at the Michigan Agricultural Experiment Station to ascertain the possibility of monthly storeability of high-fat frozen cream over an extended period. About the middle of each month thereafter for 12 consecutive months 30 gallons of fresh cream testing approximately 50 to 55 per cent fat were treated and frozen. By division and subdivision resulting from the various treatments, the original lot of cream was packaged into a total of 218 glass, tin and paper containers. Each experimental sample was of approximately three-fourths of one pint. Separate samples were packaged for flavor examination at 6- and at 12-months' storage. The 12-months' samples were examined at 3- and at 24-months' storage also. In all, the study involves approximately 3,700 flavor examinations and judgments by each of two judges.

## EXPERIMENTAL

The cream used in these studies was separated from fresh, raw, mixed milk at 100° F. The cream thus obtained was divided at once into three series of which one was pasteurized at 150° F. for 30 minutes; a second at 165° F. for 15 minutes; and the third at 185° F. for 5 minutes. Precautions were taken against copper contamination during the handling and processing of the cream, the pasteurization being accomplished in a stainless-steel-jacketed vat.

Each series was then subdivided into three lots which were homogenized at 0, 1500, and 3000 pounds pressure respectively. After homogenization the cream was cooled to 50° F. in ice water.

Each series thus pasteurized and homogenized was then subdivided into four units, one serving as a control; a second having 1 ppm. copper added as copper sulphate; a third having 10-per cent sugar added; and the fourth having both sugar and copper added at the rates previously mentioned.

Immediately following cooling and treatment, sufficient portions of the samples for study were put into eight-ounce mayonnaise-type glass jars, into pint Sealright paper cartons and into number two, "C"-enamel tin cans.

When a unit was packaged, the packages were taken at once to a −10° F. room for freezing. In this room the samples remained as the experiment dictated.

Flavor examinations of the fresh 3-, 6-, 12- and 24-months' storage cream were made by two experienced judges. The intensity of the oxidized flavor was designated as follows: ? = doubtful oxidized flavor; + = slight oxidized flavor; ++ = distinct oxidized flavor; and +++ = very pronounced oxidized flavor.

## RESULTS

*Influence of the time and temperature of pasteurization upon the development of the oxidized flavor in frozen cream.* That pasteurization is absolutely essential in any type of cream designated for frozen storage is taken for granted. At three-months' storage, the non-pasteurized, frozen cream samples had very strong rancid, putrid, cheesy or bitter flavors without exception.

Of the three pasteurization temperatures involved, pasteurization at 150° F. for 30 minutes was the least effective so far as stabilizing the flavor of the cream upon storage was concerned. Even so, the cream thus treated was sometimes of good flavor quality as shown by the flavor data obtained

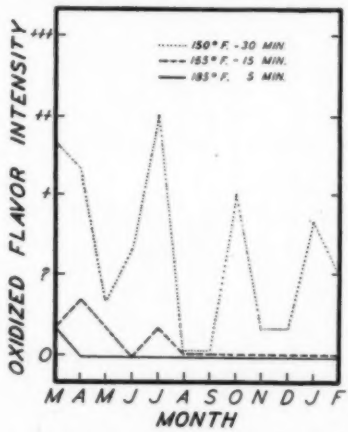


FIG. 1. The influence of various temperatures of pasteurization upon the development of the oxidized flavor in cream during 6-months' storage at – 10° F.

at 6-months' storage and presented in figure 1. However, this low-temperature pasteurization of cream for frozen-storage purposes would appear to be too risky a procedure for commercial application.

Between the pasteurization temperatures of 165° F. for 15 minutes and 185° F. for 5 minutes, there appeared to be little choice. Both temperature treatments were highly effective in preventing the development of the oxidized flavor in high-fat, copper-free cream upon frozen storage. However, the 185° F., 5-minute heat treatment seemed slightly more effective in preventing oxidation than the heat treatment of 165° F. for 15 minutes. The higher heat treatment imparted a slightly more cooked flavor to the cream which did not disappear even in one year of frozen storage. This would seem to be further proof that the 185° F., 5-minute pasteurization exerted greater stabilizing influence against spontaneous development of the oxidized flavor. The presence of this cooked flavor supports the findings of

Gould and Sommer (6) that the substance or substances causing the cooked flavor have antioxidizing properties.

*The effect of copper contamination on oxidized flavor development of frozen cream.* As copper contamination is the most common cause of oxidized flavor development in dairy products, 1 ppm. of copper was added to the cream after pasteurization to ascertain what effect it might have upon the oxidized flavor development in the cream produced at different seasons of the year.

The data presented in figure 2 show that when 1 ppm. copper was added to the cream after pasteurization that the oxidized flavor invariably developed regardless of the season during which the cream was produced.

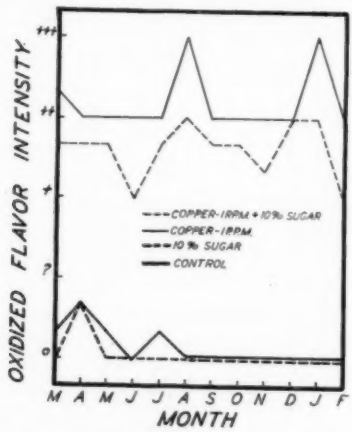


FIG. 2. The influence of various treatments upon the development of oxidized flavor in cream pasteurized at 165° F. for 15 minutes during 6-months' storage at −10° F.

The copper-induced oxidized flavor readily developed within three months of frozen storage and became more intense upon extended storage. The intensity of the flavor defect was greatest in the cream pasteurized at 150° F. for 30 minutes, was less intense at the 165° F., 15-minute heat treatment and least at the 185° F., 5-minute pasteurization. However, the oxidized flavor development in the cream heated to 185° F. for 5 minutes was sufficient to render it unusable.

The addition of both 1 ppm. copper and 10-per cent sucrose to the cream resulted in the development of a slightly less intense oxidized flavor than when 1 ppm. copper alone was added. The presence of the sugar might have obscured somewhat the off-flavor.

*The influence of homogenization on flavor of frozen cream.* Homogenization was found to have a very slight inhibitory effect on copper-induced oxidation (Figures 3 and 4), but was effective in preventing spontaneous oxidation when the cream was pasteurized at 150° F. for 30 minutes. Inas-

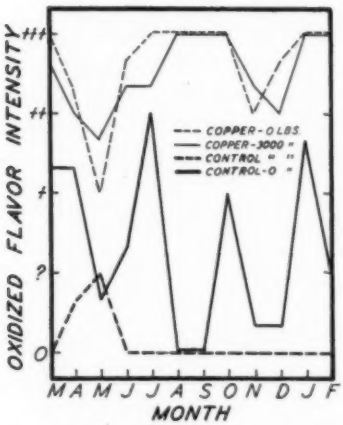


FIG. 3. The influence of homogenization upon the development of oxidized flavor in copper treated cream pasteurized at 150° F. for 30 minutes during 6-months' storage at -10° F.

much as this oxidative-inhibitory action of homogenization was slight in the samples containing 1 ppm. copper (Figure 3), and that copper-free cream, when adequately pasteurized, had excellent flavor quality upon storage without homogenization (Figure 4), homogenization of the cream prior to freezing would appear to have little commercial significance.

*Influence of the type of container used for cream storage.* All the cream samples in these studies were stored in glass, paper and tin to ascertain the effect upon flavor. The data showed no consistent difference in the flavor

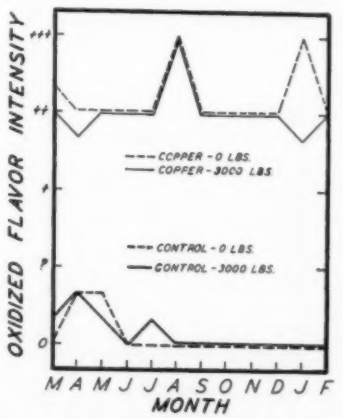


FIG. 4. The influence of homogenization upon the development of oxidized flavor in copper-treated cream pasteurized at 165° F. for 15 minutes during 6-months' storage at -10° F

EXPERIMENTAL DATA

Freezing and Storage of Sweet Cream

Sample April 12, 1940 Factor studied Intensity of oxidized flavor Date examined (illegible)

Treatment

| Original Cream | Heat Treatment | Storage In | 0# Control | 0# 1 ppm Cu | 0# 18% Sucrose | 0# Cu + Sucrose | 1000# Control | 1000# 1 ppm Cu | 1000# 18% Sucrose | 1000# Cu + Sucrose | 2000# Control | 2000# 1 ppm Cu | 2000# 18% Sucrose | 2000# Cu + Sucrose |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | After 6 months at 0°F. | | | | | | | | | | | |
| Raw (Separated at 100-110°F.) | 150°F.- 30 min. | Glass | + | ⇔ | ? | ⇔ | + | ⇔ | + | ⇔ | - | ⇔ | - | + |
| | | Paper | ⇔ | ⇔⇔ | + | ⇔ | + | ⇔⇔ | + | ⇔ | + | ⇔ | - | ⇔ |
| Tests: | | Tin | + | + | - | ⇔ | + | ⇔ | - | ⇔ | - | ⇔ | + | ⇔ |
| Fat 32.3 | | | After 12 months at 0°F. | | | | | | | | | | | |
| Acid. | | Glass | + | ⇔⇔ | - | ⇔⇔ | - | ⇔⇔ | - | ⇔ | - | ⇔⇔ | - | ⇔ |
| Flav. | | Paper | ⇔ | ⇔⇔ | - | ⇔ | ⇔ | ⇔⇔ | - | ⇔ | + | ⇔⇔ | + | ⇔ |
| Caro-tene | | Tin | + | ⇔⇔ | - | ⇔⇔ | - | ⇔⇔ | - | ⇔ | - | ⇔⇔ | - | ⇔ |
| Bact. | | | After 6 months at 0°F. | | | | | | | | | | | |
| Misc. | 165°F.- 15 min. | Glass | - | ⇔ | - | + | - | ⇔ | - | + | - | ⇔ | - | + |
| | | Paper | + | ⇔ | + | + | + | ⇔ | + | + | + | ⇔ | + | ⇔ |
| | | Tin | - | ⇔ | - | ⇔ | - | ⇔ | - | + | - | + | - | + |
| | | | After 12 months at 0°F. | | | | | | | | | | | |
| | | Glass | - | ⇔⇔ | - | ⇔ | - | ⇔ | - | + | - | ⇔⇔ | - | ⇔ |
| | | Paper | - | ⇔⇔ | - | ⇔ | ? | ⇔ | - | + | - | ⇔ | - | + |
| | | Tin | - | ⇔⇔ | - | ⇔ | - | ⇔⇔ | - | + | - | ⇔ | - | + |
| | | | After 6 months at 0°F. | | | | | | | | | | | |
| | 165°F.- 5 min. | Glass | - | + | - | ⇔ | - | ⇔ | - | + | - | ⇔ | - | + |
| | | Paper | - | + | - | + | - | ⇔ | - | + | - | ⇔ | - | + |
| | | Tin | - | + | - | + | - | ⇔ | - | ⇔ | - | ⇔ | - | + |
| | | | After 12 months at 0°F. | | | | | | | | | | | |
| | | Glass | - | ⇔⇔ | - | ⇔ | - | ⇔ | - | + | - | ⇔ | - | + |
| | | Paper | - | ⇔ | - | + | - | ⇔ | - | + | - | ⇔ | - | + |
| | | Tin | - | ⇔ | - | + | - | ⇔ | - | - | - | ⇔ | - | + |

FIG. 5. Flavor data on one series of cream samples after 6- and 12-months' storage.

of the frozen cream as a result of the specific type of container in which the cream was stored. Occasionally, cream pasteurized at 150° F. for 30 minutes and stored in paper containers had slightly more intense off-flavor than did similar cream stored in glass or in tin containers (Figure 5). However, this observation was not consistent throughout the study.

*Effect of season of the year on keeping quality of frozen cream.* Seasonal variations in the composition of cream apparently had very little effect on the stability of flavor of cream against oxidative changes during storage.

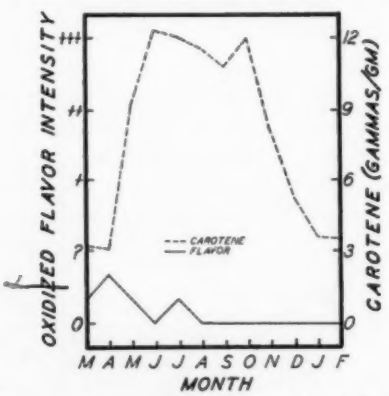


FIG. 6. The relation between carotenoids and oxidized flavor development in cream pasteurized at 165° F. for 15 minutes during 6-months' storage at −10° F. (carotenoids are expressed as carotene in this graph).

During the period of the study the carotenoids of cream reached and maintained a high peak of 11 to 12 micrograms per gram of fat from June to October inclusive (Figure 6), yet cream during this period was as susceptible to copper-induced oxidation as that produced during the months when the carotenoids were low. Apparently, therefore, one may store cream successfully at one season of the year as well as at any other as far as the influence of the carotenoids on the stability of flavor is concerned. Thus, no special seasonal treatment of cream intended for frozen storage would seem to be necessary.

A detailed report of the influence of several factors upon the amount and stability of carotenoids in frozen cream has been presented by Trout, Moore and Scheid (12) and need not be repeated here.

*The influence of the length of the storage period on the flavor of frozen cream.* Data in table 1 show the effect of 3-, 6-, 12- and 24-months' storage

TABLE 1

*The flavor of non-homogenized cream stored in glass containers at −10° F. for various periods of time. (Avg. 12 monthly samples taken monthly throughout the year)*

| Treatment of cream | Oxidized flavor* of cream pasteurized at | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 150° F.–30 min. and stored (months) | | | | 165° F.–15 min. and stored (months) | | | | 185° F.–5 min. and stored (months) | | | |
| | 3 | 6 | 12 | 24 | 3 | 6 | 12 | 24 | 3 | 6 | 12 | 24 |
| Control | 0.4 | 1.0 | 1.8 | 2.3 | 0.0 | 0.1 | 0.1 | 0.7 | 0.0 | 0.0 | 0.0 | 0.1 |
| 1 ppm. Cu. added | 3.4 | 3.6 | 4.0 | 4.0 | 2.7 | 3.2 | 3.6 | 3.9 | 2.0 | 3.8 | 3.2 | 3.3 |
| 10% sucrose " | 0.3 | 0.2 | 1.0 | 1.3 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.1 | 0.0 | 0.1 |
| 1 ppm. Cu. + 10% sucrose added | 2.7 | 3.4 | 3.7 | 3.9 | 2.2 | 2.6 | 2.9 | 3.7 | 1.5 | 2.2 | 2.4 | 3.4 |

* 0, no oxidized flavor, –
1, questionable oxidized flavor, ?
2, slight oxidized flavor, +
3, distinct oxidized flavor, ++
4, very pronounced oxidized flavor, +++

on the flavor of frozen cream. The storeability of the cream depended upon the treatment which the cream received prior to freezing, particularly the heat treatment and the contamination with copper. Generally, if the cream showed no indication of oxidized flavor development at three months, the cream showed little or no oxidized flavor at 6- and at 12-months' storage. Cream pasteurized at 185° F. for 5 minutes and not contaminated with copper exhibited practically no oxidized flavor development at 24-months' storage.

*Influence of initial titratable acidity on oxidized flavor development in frozen cream.* There appeared to be a high positive correlation between the initial titratable acidity and the intensity of the oxidized flavor development upon storage when the cream was pasteurized at 150° F. for 30 minutes

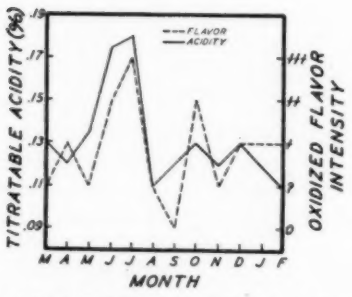


FIG. 7. The influence of the initial titratable acidity upon the development of oxidized flavor in cream pasteurized at 150° F. for 30 minutes during 12-months' storage at – 10° F.

(Figure 7), but such correlation did not seem to exist when the cream was pasteurized at 165° F. for 15 minutes (Figure 8).

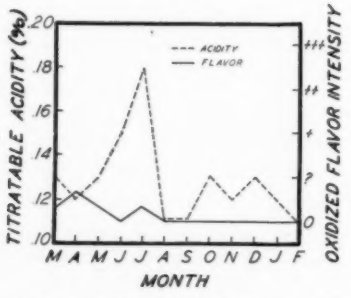


FIG. 8. The influence of the initial titratable acidity upon the development of oxidized flavor in cream pasteurized at 165° F. for 15 minutes during 12-months' storage at – 10° F.

*The influence of storage on the pH of monthly samples of cream.* The pH determinations made on the monthly samples of cream, pasteurized, fresh and after 6- and 12-months' storage at – 10° F. showed a slight lower-

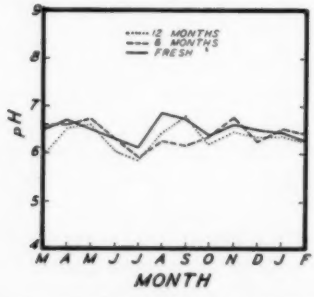


FIG. 9. The pH of cream pasteurized at 165° F. for 15 minutes as influenced by the length of storage at – 10° F.

ing of the pH as the period of storage increased (Figure 9). There appeared to be no seasonal trend in the pH or any direct relationship between the pH and the flavor of the stored cream.

*The influence of sucrose upon the flavor of frozen cream.* The addition of 10 per cent sucrose to cream prior to storage appeared to have little influence upon the flavor of the cream upon storage (Table 1).

When 10 per cent sugar and 1 ppm. copper were added to the cream, a slight advantage in favor of the samples containing sugar was noted. This may have been due to the masking effect of the sugar. However, under these conditions sugar did not improve the flavor sufficiently to be of any commercial significance. The chief advantages of sugar additions, therefore, seem to be associated with other effects than flavor.

## SUMMARY AND CONCLUSIONS

Thirty gallons of cream, averaging throughout the year 52.5 per cent fat, were processed and stored at – 10° F. monthly for a 12-month period. Flavor examinations were made at 3-, 6-, 12-, and 24-months' storage. Possible flavor-affecting factors studied were: temperature of pasteurization, copper contamination, homogenization, addition of sucrose, type of container, season of the year, length of storage, initial titratable acidity and hydrogen-ion concentration. The studies involved approximately 3,700 flavor examinations and judgments by each of two experienced judges.

Fresh, high-quality cream, pasteurized at 165° F. for 15 minutes or at 185° F. for 5 minutes withstood – 10° F. storage for 3, 6, or 12 months without appreciable development of the oxidized flavor. The temperature of 185° F. for 5 minutes resulted in a slightly superior keeping quality of the cream, particularly at 24 months' storage, than did the temperature of 165° F. for 15 minutes. The pasteurization temperature of 150° F. for 30 minutes was inadequate for stabilizing the flavor of the cream upon storage.

When 1 ppm. copper was added to the cream following pasteurization, the cream invariably became oxidized even upon 3-months' storage regardless of the temperature of pasteurization. Homogenization, at 3,000 pounds pressure, although slightly beneficial, did not prevent the development of copper-induced oxidation upon storage when 1 ppm. copper was added to the cream. Homogenization, however, was beneficial in retarding spontaneous oxidation when the cream was pasteurized at 150° F. for 30 minutes. When high-quality cream, produced and handled away from copper contamination was adequately pasteurized, further advantage so far as stability of flavor upon storage was concerned was not secured by homogenization.

The addition of 10 per cent sucrose appeared to have little effect upon the flavor of stored cream. When 1 ppm. copper and 10-per cent sugar were both present in the cream the oxidized flavor developed was less intense than when copper only was present. However, this was attributed to the masking effect of the sugar.

The type of container, glass, paper, or tin had little influence upon the flavor of the cream during storage, particularly when the cream was pasteurized at 165° F. for 15 minutes or at 185° F. for 5 minutes.

Despite a wide range in the seasonal carotenoid content of cream, cream produced during one season of the year was stored as satisfactorily as that produced at another season.

The length of the storage period of cream assumes less importance when the cream stored is of high quality, free of copper contamination and is pasteurized at sufficiently high temperatures to yield anti-oxidizing properties. If the cream were susceptible to off-flavor development, the off-flavors were most generally present at 3 months of storage.

The initial titratable acidity was found to have little influence on the flavor of the stored cream when the cream was pasteurized at 165° F. for 15 minutes or higher. There appeared to be a direct correlation between a high titratable acidity and susceptibility toward off-flavor development in the stored cream when the cream was pasteurized at 150° F. for 30 minutes.

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# THE STABILITY OF THE FAT EMULSION OF FROZEN CREAM[1]

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One of the problems of frozen cream is that of destabilization of the fat emulsion or "oiling off" of the cream. Despite the fact that the fat may be re-emulsified by homogenization, the use in ice cream mix of cream which "oils off" upon defrosting may give rise to such problems as delayed whipping of the mix, defective body and texture of the ice cream, or to composition control. Several factors, such as the speed of freezing, the addition of sugar, and the length of storage are known to affect the stability of the fat emulsion in cream.

The whole subject of frozen cream has been very well reviewed by Dahle (1) and need not be repeated here. Since this review, however, Hening (4) observed that cream separated from milk in which the fat was in a solid state not only "oiled off" less when it was frozen, thawed and heated than cream separated in the regular manner, but also that such cream "oiled off" less than regular cream to which sugar had been added prior to freezing. Various investigators have added sugar to the cream prior to freezing in order to prevent or reduce the "oiling off" of the product. Dahle, Lawhorn, and Barnhart (3) showed that sugar to the extent of 10 and 15 per cent of the cream reduced "oiling off" approximately 55 to 65 per cent.

Since adequate homogenization stabilizes fat emulsions, the assumption is only natural that homogenization of the cream prior to freezing would prevent "oiling off" of the cream upon defrosting and heating. However, as pointed out by Dahle and Josephson (2), such cream may "oil off" more than creams not homogenized.

Inasmuch as variously treated creams were available from flavor studies made by Trout and Scheid (5), an opportunity was at hand for a study of the comparative "oiling off" of cream as influenced by several factors.

## EXPERIMENTAL

The cream used in these studies was separated during the period from October to February inclusive, from fresh, raw, mixed milk at 100° F. The cream was divided into three series of which one was pasteurized at 150° F. for 30 minutes; a second at 165° F. for 15 minutes; and the third at 185° F. for 5 minutes.

Each series was then subdivided into three lots which were homogenized at 0, 1500, and 3000 pounds pressure respectively. Following processing, 10 per cent sugar was added to a portion of each lot.

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The cream was frozen by one of four methods; namely, by rotating the bottles containing the cream in a 95 per cent alcohol-dry-ice mixture; by placing the bottles on dry ice; by setting the bottles in a −10° F. room; and by delayed freezing secured by placing the bottles in an insulated bag before placing them in the −10° F. room. The time to freeze the samples solid according to the above methods was approximately 3, 6, 20 and 180 minutes, respectively.

TABLE 1

*Influence of the speed of freezing on the stability of the fat emulsion of cream*

| Sample | Per cent "oiling off" of cream after three months' storage when cream was frozen in | | | |
|---|---|---|---|---|
| | 3 minutes, using dry ice and alcohol | 6 minutes, using dry ice | 20 minutes in −10° F. room | 180 minutes in −10° F. room, bottles insulated |
| | Series I—52% cream (October) | | | |
| 1 | 91.3 | 96.2 | 100.0 | 98.1 |
| 2 | 90.4 | 96.2 | 97.1 | 98.1 |
| 3 | 88.5 | 94.2 | 98.1 | 98.1 |
| 4 | 88.5 | 92.3 | 96.2 | 98.1 |
| 5 | 91.3 | 96.2 | 95.2 | 99.0 |
| 6 | 91.3 | 95.2 | 97.1 | 98.1 |
| 7 | 89.4 | 94.2 | 97.1 | 98.1 |
| 8 | 88.5 | 95.2 | 96.2 | 98.1 |
| 9 | 91.3 | 95.2 | 96.2 | 96.2 |
| 10 | 86.5 | 95.2 | 96.2 | 98.1 |
| Avg. | 89.7 | 95.0 | 97.0 | 98.1 |
| | Series II—53% cream (November) | | | |
| 1 | 83.0 | 92.5 | 96.2 | 98.1 |
| 2 | 81.1 | 92.5 | 98.1 | 98.1 |
| 3 | 83.0 | 90.6 | 96.2 | 98.1 |
| 4 | 84.9 | 94.3 | 94.3 | 100.0 |
| 5 | 83.0 | 94.3 | 96.2 | 100.0 |
| 6 | 81.1 | 92.5 | 96.2 | 100.0 |
| 7 | 83.0 | 92.5 | 96.2 | 100.0 |
| 8 | 83.0 | 94.3 | 96.2 | 98.1 |
| 9 | 84.9 | 92.5 | 96.2 | 98.1 |
| 10 | 83.0 | 92.5 | 96.2 | 100.0 |
| Avg. | 83.0 | 92.8 | 96.2 | 99.1 |

Fat emulsion stability was measured according to a method which was very similar to that used by Webb and Hall (6). The method consisted of weighing nine grams of fresh cream into regulation 9-gram, 50 per cent, cream test bottles, freezing by different methods and holding for various periods of time. Following the freezing period, the samples were thawed at 100° F., the bottles filled to the 50 per cent mark with 100° F. water, and then centrifuged in a Babcock centrifuge for 30 minutes. After holding the centrifuged samples 24 hours at 40° F. they were reheated for fifteen minutes in water tempered to 100° F. and re-centrifuged for thirty minutes as

before. The fat columns were then tempered and read as in the Babcock cream test.

## RESULTS

*Influence of speed of freezing on stability of fat emulsion of frozen cream.* Ten samples each of October and November cream containing 52 and 53 per cent fat respectively were weighed out into regulation 9-gram, 50 per cent, cream test bottles and were frozen by various methods in order to ascertain the effect of the speed of freezing upon the destabilization of the fat emulsion. The data presented in table 1 show that the speed of freezing influences the stability of the fat emulsion. The difference in percentage "oiling off" between fast and slow freezing, however, was not as great as might be expected considering the great difference in the freezing time of

TABLE 2

*The influence of the heat treatment and the percentage fat upon the stability of the fat emulsion in cream after 6 months' storage at −10° F.*

| Heat treatment | Per cent fat in cream | Per cent "oiling-off" of cream when frozen | |
|---|---|---|---|
| | | Without sugar | With 10 per cent sugar added |
| 150° F. for 30 min. | 45 | 91.1 | 77.8 |
| 165° F. for 15 min. | 45 | 71.1 | 62.2 |
| 185° F. for 5 min. | 45 | 88.9 | 84.4 |
| 150° F. for 30 min. | 50 | 92.0 | 84.0 |
| 165° F. for 15 min. | 50 | 88.0 | 79.0 |
| 185° F. for 5 min. | 50 | 94.0 | 82.0 |
| 150° F. for 30 min. | 54 | 92.6 | 89.8 |
| 165° F. for 15 min. | 54 | 92.6 | 85.2 |
| 185° F. for 5 min. | 54 | 91.7 | 90.7 |

the samples. There appeared to be significant differences in the stabilities of the fat emulsions of the creams frozen within three minutes and those frozen over a longer period.

*Influence of the time and temperature of pasteurization upon the stability of the fat emulsion of frozen cream.* Data showing the effect of the time and temperature of pasteurization upon the destabilization of the fat emulsion in the cream after six months' storage are presented in tables 2 and 3. Generally, less "oiling off" occurred when the cream was pasteurized at 165° F. for 15 minutes than when pasteurized either at 150° F. for 30 minutes or at 185° F. for 5 minutes. The more stable emulsion resulting from pasteurization at 165° F. for 15 minutes may be accounted for in part by less agitation than that encountered when pasteurized at 150° F. for 30 minutes and by less heat than that used when pasteurized at 185° F. for 5 minutes.

*Influence of added sugar upon the fat stability.* The presence of sugar in cream markedly reduced the "oiling off" when the cream was held frozen

24 hours (Table 3). The combination of homogenization and added sugar seemed to be more beneficial in preventing "oiling off" than either alone regardless of the length of storage.

The influence of sugar in stabilizing the fat emulsion was greatly lessened as the length of frozen storage extended. At the 3- and 12-month storage periods, sugar had only a slight effect upon the stability of the fat emulsion, as determined by the method employed in these studies.

TABLE 3

*The influence of the length of frozen storage upon the stability of the fat emulsion. (Average 3 trials, cream averaging 50 per cent fat)*

| Heat treatment | Per cent "oiling off" of cream when homogenized at | | | | | |
|---|---|---|---|---|---|---|
| | 0 lbs. and frozen | | 1500 lbs., frozen | | 3000 lbs., frozen | |
| | Without sugar | With 10% sugar | Without sugar | With 10% sugar | Without sugar | With 10% sugar |
| | Not frozen | | | | | |
| 150° F. for 30 min. | 36.4 | 36.0 | 10.0 | 5.0 | 4.0 | 5.0 |
| 165° F. for 15 min. | 40.0 | 34.0 | 2.4 | 3.6 | 2.0 | 2.6 |
| 185° F. for 5 min. | 48.0 | 36.0 | 4.6 | 4.0 | 4.4 | 5.6 |
| | Frozen, stored 24 hours | | | | | |
| 150° F. for 30 min. | 86.0 | 58.4 | 71.6 | 31.6 | 66.0 | 27.6 |
| 165° F. for 15 min. | 66.0 | 52.0 | 66.0 | 14.0 | 70.0 | 20.0 |
| 185° F. for 5 min. | 74.0 | 62.0 | 66.0 | 27.0 | 64.0 | 18.0 |
| | Frozen, stored 3 months | | | | | |
| 150° F. for 30 min. | 92.0 | 82.0 | 86.0 | 74.0 | 84.0 | 70.0 |
| 165° F. for 15 min. | 84.0 | 76.0 | 82.0 | 70.0 | 82.0 | 68.0 |
| 185° F. for 5 min. | 92.0 | 84.0 | 78.0 | 66.0 | 74.0 | 72.0 |
| | Frozen, stored 12 months | | | | | |
| 150° F. for 30 min. | 82.0 | 78.0 | 84.0 | 76.0 | 82.0 | 72.0 |
| 165° F. for 15 min. | 78.0 | 74.0 | 78.0 | 66.0 | 78.0 | 72.0 |
| 185° F. for 5 min. | 86.0 | 82.0 | 78.0 | 72.0 | 70.0 | 74.0 |

*Influence of homogenization upon the fat stability.* Homogenization had a very definite stabilizing effect upon the stability of the fat emulsion of the fresh, non-frozen cream (Table 3). In fact, the "oiling off" in the non-frozen product was practically eliminated in fresh cream upon the use of either 1500 or 3000 pounds pressure. On the other hand, the data show that freezing and storage destroyed in large part the effects of homogenization. Apparently, little is to be gained by homogenization of cream prior to freezing insofar as fat-emulsion stability is concerned when the cream is to be stored frozen for three months or longer.

*Influence of length of storage on the stability of the fat emulsion.* Considerable "oiling off" was noted in the fresh non-frozen cream when examined according to the method described. However, such cream was more stable than that frozen and held only 24 hours (Table 3). The frozen cream stored 24 hours generally showed less "oiling off" than did that which had been stored for 3 months or longer. The 3 months' storage period seemed to be ample to effect maximum fat emulsion destabilization as a result of the freezing process.

*Effect of fat percentages upon the stability of the fat emulsion.* The percentage of fat destabilized usually increased as the percentage of fat in the cream increased regardless of the temperature and time of pasteurization (Table 2).

## SUMMARY AND CONCLUSIONS

The percentage "oiling off" of high-testing-frozen cream was observed, using a method similar to that of Webb and Hall (6) in which 9-gram samples of fresh cream were weighed into 50 per cent, cream test bottles, were then frozen, stored, defrosted and centrifuged.

Fast freezing of the cream, although more effective in stabilizing the fat emulsion than slow freezing, did not prevent "oiling off" of the cream.

Frozen cream pasteurized at 165° F. for 15 minutes exhibited less "oiling off" than frozen cream which had been pasteurized at 150° F. for 30 minutes or at 185° F. for 5 minutes.

The addition of 10 per cent sucrose to the cream reduced the amount of "oiling off" as a result of freezing, but did not prevent it. The effectiveness of added sugar in reducing "oiling off" of fat in frozen cream seemed to be greater with homogenized than with non-homogenized cream.

Although homogenization very definitely stabilized the fat emulsion of non-frozen cream, its influence was practically eliminated upon freezing. Little would seem to be gained so far as "oiling off" is concerned by homogenizing cream intended for frozen storage.

The maximum destabilizing effect of freezing and storage occurred within the first 3 months of storage.

Higher testing cream tended to "oil off" as a result of freezing slightly more than did lower testing cream.

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# LIVE WEIGHT AND MILK-ENERGY YIELD IN THE NEBRASKA STATION DAIRY HERD

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## EXPERIMENTAL OBSERVATIONS

Since 1921 it has been a practice in the Nebraska Station dairy herd to weigh each cow on three consecutive days at the middle of each calendar month. The live weights used in this article are based on the average of the three weighings for the given month, appropriate to the particular analysis.

Milk and fat yields are based on continuous weighings of each milking and monthly fat percentage determinations. Milk-energy yield is computed from the milk and fat yields in terms of 4 per cent milk, designated FCM, by the formula, $FCM = 0.4M + 15F$, in which M is pounds of milk and F is pounds of fat. One pound FCM, by this formula = 340 kilocalories of milk energy and 0.034 pounds of milk protein (3), regardless of the actual fat percentage of the milk. Laboratory determinations at the Pennsylvania Institute of Animal Nutrition show a correlation between actual calorie yield and FCM-computed calorie yield of 0.997 (2, footnote 1). Accordingly the present milk-energy yields expressed as FCM may be accepted as of substantially the same degree of accuracy as the milk and fat yields on which they are based. Throughout this article FCM is given in pounds per day.

All cows were registered and records have been kept, including dates of birth, breeding, and calving.

The present analysis includes every lactation of every cow that has freshened in the herd during the 20-year period 1921–1940, except: lactations begun by premature calving (gestation 265 days or less); lactations in which the record of milk yield terminates short of 243 days (8 months); lactations in which record of the 3-day mid-month live weight next after calving is lacking. As thus restricted the observations provide: 131 lactations by 63 Ayrshires; 77 lactations by 43 Guernseys; 367 lactations by 147 Holsteins; 171 lactations by 81 Jerseys; a total of 746 lactations by 334 cows.

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### *Calving Interval and Length of Record*

The calving interval distributions show very pronounced modes, falling in the 13th month for Holsteins and in the 12th month for each of the other breeds. Consequently, in inter-cow comparisons, 8 months is the longest uniform length of record that can be used and avoid variation in yield associated with variation in length of calving interval. For this reason, principal attention is directed to the 243-day partial-lactation milk-energy yield, designated $FCM_8$.

Consideration is given also to the 10-month record, designated $FCM_{10}$. This is the total yield for not less than 243 days nor more than 305 days divided by 305, even though the actual days in milk may be less than 305. There are thus 746 $FCM_{10}$ records corresponding to the 746 $FCM_8$ records. $FCM_{10}$ represents the type of record now extensively used in proved sire work, etc.

Among the 746 lactations there are 300 which embrace a full 365 days in milk. In all these cases the calving interval exceeds 12 months. The 365-day records designated $FCM_{12}$ are given attention as a separate group. Each $FCM_{12}$ record has also a record in the $FCM_{10}$ and $FCM_8$ categories. In general, the $FCM_{12}$ records represent superior lactations of cows entered in the more difficult and more impressive 365-day division of advanced registry testing.

### *Live Weight at Various Stages of Lactation and Yield*

Previous studies (8) of the live weights of the Station cows have shown wide differences in live weight associated with the stage of reproductive cycle. For example, first lactation Holsteins had an average weight of 1198 pounds at 15 days after calving and 1500 pounds at 1 day before the next calving. Obviously the relation of yield to live weight may vary according to the stage of lactation at which live weight is measured.

The present live-weight data are considered at 10 stages of lactation: average of the three consecutive-day mid-month weighings next after calving, designated $W_1$; average of similar weighings one month later, designated $W_2$; and so on to $W_{10}$, average of the three consecutive-day mid-month weighings 9 months after $W_1$. Table 1 presents various relations between the W's and FCM's.

*Correlations.* The following extract from table 1 shows how the correlation between live weight and yield is affected by stage of lactation at which the live weight is measured:

| Breed | Correlation, r, between $FCM_8$ and $W_1$ | Correlation, r, between $FCM_8$ and $W_{10}$ |
|---|---|---|
| Guernsey | 0.24 | 0.02 |
| Ayrshire | 0.45 | 0.18 |
| Jersey | 0.58 | 0.32 |
| Holstein | 0.60 | 0.43 |
| All 4 | 0.83 | 0.75 |

Clearly, milk-energy yield is more closely related to live weight when live weight is measured within 31 days after calving, $W_1$, than it is when the live weight is measured at a later stage of lactation. This finding is in agreement with previous results (4) from data by the Bureau of Dairy Industry.[1]

It is easy to find a probable explanation of why milk-energy yield is more closely related to $W_1$ than it is to $W_{10}$, in inter-cow comparisons. A high-yielding cow tends to gain less weight from $W_1$ to $W_{10}$ than does a low-yielding cow, and accordingly at $W_{10}$ there is some tendency for high weight and low yield or low weight and high yield, to go together. Live weight is a combination of size, in the sense of skeletal dimensions, and of condition of flesh or fatness. In good dairy cows fatness at $W_1$ is positively correlated with yield, while fatness at $W_{10}$ is apt to be negatively correlated with yield. In young cows, gain in weight due to growth behaves much the same as gain in weight due to fatness, so far as concerns the correlation between live weight at $W_{10}$ and yield.

From both practical[2] and biological points of view the choice and use of $W_1$ is justified.

An explanation of differences in the correlations, as between breeds, is not so readily forthcoming. The differences are probably not breed differences but merely differences in the samples at hand. No doubt there is a physiological connection between $W_1$ and $FCM_8$ in the cow. In case of wild cattle where lactation must satisfy only the moderate demands of the calf the connection may be rather loose but in dairy cows where lactation must satisfy the immoderate demands of the human master the connection may become quite close. That is, as the lactation function becomes more highly developed under the influence of artificial selection $W_1$ and $FCM_8$ become more closely related. It is suggested that the correlation of 0.24 in the Guernsey records and 0.60 in the Holstein records signifies that the Holsteins are more highly developed (genetically) in the lactation function than the Guernseys, in these particular samples.

However, the correlation coefficient reflects not only closeness of connection between $W_1$ and $FCM_8$ but also, in material of the present kind, the degree of regression. In the present samples the breed of largest cows (Holstein) has the largest milk-energy yield in proportion to live weight and thus when the records of the four breeds are thrown together the regression

[1] In the directions for guidance of D.H.I.A. testers one item specifies recording live weight of each cow. This item could be made more explicit and much more valuable by directing the tester, upon each visit at each herd, to measure and record the live weight of each cow that has freshened in the herd since his last visit (corresponding in time to $W_1$). We recommend the adoption of such a system of live weight recording in D.H.I.A. practice.

[2] Possibly measuring live weight within, say, five days after calving might be better than within 31 days, but the 31-day allowance is necessary under the monthly testing system.

TABLE 1

*Correlations and regressions for milk-energy yield and live weight according to the stage of lactation at which live weight is measured*

| Stage | Mean* | C V† | Coefficient of correlation‡ | | | Coefficient of regression§ | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $FCM_{10}$ | | $FCM_s$ | |
| | | | $W_1$ | $FCM_{10}$ | $FCM_s$ | 100b′ | b | 100b′ | b |
| Ayrshire. n = 131. C V: $FCM_{10}$ = 22.1; $FCM_s$ = 21.4. Range in $W_1$ = 755 – 1376 | | | | | | | | | |
| $W_1$ | 1031 | 11.6 | 1.00 | 0.40 | 0.45 | 2.29 | 0.76 | 2.79 | 0.84 |
| $W_2$ | 1025 | 11.3 | 0.95 | 0.32 | 0.36 | 1.88 | 0.62 | 2.30 | 0.69 |
| $W_3$ | 1034 | 11.3 | 0.93 | 0.27 | 0.32 | 1.61 | 0.54 | 2.03 | 0.61 |
| $W_4$ | 1044 | 11.8 | 0.87 | 0.23 | 0.27 | 1.26 | 0.42 | 1.60 | 0.49 |
| $W_5$ | 1054 | 11.5 | 0.87 | 0.23 | 0.28 | 1.29 | 0.44 | 1.67 | 0.51 |
| $W_6$ | 1064 | 12.4 | 0.84 | 0.20 | 0.25 | 1.04 | 0.36 | 1.39 | 0.43 |
| $W_7$ | 1075 | 12.2 | 0.82 | 0.15 | 0.20 | 0.78 | 0.27 | 1.11 | 0.35 |
| $W_8$ | 1095 | 11.7 | 0.80 | 0.14 | 0.20 | 0.74 | 0.26 | 1.15 | 0.37 |
| $W_9$ | 1120 | 11.6 | 0.79 | 0.13 | 0.18 | 0.67 | 0.24 | 1.04 | 0.34 |
| $W_{10}$ | 1146 | 11.4 | 0.78 | 0.12 | 0.18 | 0.65 | 0.24 | 1.02 | 0.34 |
| Guernsey. n = 77. C V: $FCM_{10}$ = 23.5; $FCM_s$ = 21.6. Range in $W_1$ = 739 – 1249 | | | | | | | | | |
| $W_1$ | 960 | 12.0 | 1.00 | 0.12 | 0.24 | 0.64 | 0.23 | 1.31 | 0.43 |
| $W_2$ | 959 | 12.1 | 0.96 | 0.00 | 0.11 | 0.02 | 0.01 | 0.60 | 0.20 |
| $W_3$ | 971 | 11.9 | 0.92 | 0.02 | 0.12 | 0.13 | 0.05 | 0.65 | 0.21 |
| $W_4$ | 980 | 11.6 | 0.92 | 0.03 | 0.13 | 0.17 | 0.06 | 0.73 | 0.25 |
| $W_5$ | 988 | 11.6 | 0.91 | 0.06 | 0.14 | 0.32 | 0.12 | 0.79 | 0.27 |
| $W_6$ | 1000 | 11.8 | 0.90 | 0.02 | 0.11 | 0.08 | 0.03 | 0.59 | 0.20 |
| $W_7$ | 1021 | 11.2 | 0.88 | 0.00 | 0.09 | 0.01 | 0.00 | 0.52 | 0.18 |
| $W_8$ | 1034 | 11.0 | 0.86 | – 0.01 | 0.07 | – 0.08 | – 0.01 | 0.42 | 0.15 |
| $W_9$ | 1051 | 10.8 | 0.82 | 0.00 | 0.09 | 0.02 | 0.01 | 0.48 | 0.17 |
| $W_{10}$ | 1060 | 10.7 | 0.83 | – 0.07 | 0.02 | – 0.40 | – 0.16 | 0.13 | 0.05 |
| Holstein. n = 367. C V: $FCM_{10}$ = 20.6; $FCM_s$ = 20.0. Range in $W_1$ = 934 – 1854 | | | | | | | | | |
| $W_1$ | 1348 | 12.0 | 1.00 | 0.56 | 0.60 | 3.54 | 0.96 | 3.95 | 1.01 |
| $W_2$ | 1331 | 11.6 | 0.94 | 0.51 | 0.55 | 3.40 | 0.91 | 3.81 | 0.96 |
| $W_3$ | 1336 | 11.5 | 0.92 | 0.49 | 0.53 | 3.27 | 0.88 | 3.68 | 0.93 |
| $W_4$ | 1341 | 11.1 | 0.90 | 0.48 | 0.52 | 3.32 | 0.90 | 3.70 | 0.94 |
| $W_5$ | 1345 | 11.1 | 0.88 | 0.47 | 0.51 | 3.25 | 0.88 | 3.61 | 0.92 |
| $W_6$ | 1353 | 10.9 | 0.85 | 0.45 | 0.48 | 3.14 | 0.85 | 3.48 | 0.89 |
| $W_7$ | 1362 | 10.6 | 0.85 | 0.45 | 0.48 | 3.16 | 0.87 | 3.52 | 0.91 |
| $W_8$ | 1376 | 10.4 | 0.83 | 0.40 | 0.43 | 2.83 | 0.78 | 3.17 | 0.82 |
| $W_9$ | 1396 | 10.4 | 0.82 | 0.39 | 0.43 | 2.74 | 0.77 | 3.11 | 0.82 |
| $W_{10}$ | 1417 | 10.3 | 0.83 | 0.39 | 0.43 | 2.73 | 0.78 | 3.12 | 0.83 |
| Jersey. n = 171. C V: $FCM_{10}$ = 22.1; $FCM_s$ = 20.6. Range in $W_1$ = 596 – 1180 | | | | | | | | | |
| $W_1$ | 894 | 12.5 | 1.00 | 0.55 | 0.58 | 3.12 | 0.98 | 3.34 | 0.96 |
| $W_2$ | 893 | 12.7 | 0.96 | 0.47 | 0.50 | 2.64 | 0.83 | 2.85 | 0.82 |
| $W_3$ | 893 | 12.3 | 0.93 | 0.45 | 0.48 | 2.59 | 0.81 | 2.81 | 0.81 |
| $W_4$ | 895 | 12.1 | 0.90 | 0.41 | 0.44 | 2.39 | 0.75 | 2.60 | 0.75 |
| $W_5$ | 905 | 11.6 | 0.87 | 0.38 | 0.41 | 2.31 | 0.73 | 2.47 | 0.72 |
| $W_6$ | 912 | 11.7 | 0.87 | 0.36 | 0.39 | 2.15 | 0.69 | 2.33 | 0.69 |
| $W_7$ | 922 | 11.4 | 0.82 | 0.35 | 0.37 | 2.09 | 0.68 | 2.24 | 0.67 |
| $W_8$ | 935 | 10.6 | 0.83 | 0.35 | 0.37 | 2.25 | 0.74 | 2.39 | 0.72 |
| $W_9$ | 949 | 10.4 | 0.80 | 0.32 | 0.35 | 2.05 | 0.68 | 2.25 | 0.69 |
| $W_{10}$ | 964 | 10.1 | 0.77 | 0.29 | 0.32 | 1.87 | 0.63 | 2.11 | 0.66 |

TABLE 1 (*Continued*)

| Stage | Mean* | C V† | Coefficient of correlation‡ | | | Coefficient of regression§ | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | $W_1$ | $FCM_{10}$ | $FCM_8$ | $FCM_{10}$ | | $FCM_8$ | |
| | | | | | | 100b′ | b | 100b′ | b |
| All breeds. n = 746. C V: $FCM_{10}$ = 34.3; $FCM_8$ = 32.8. Range in $W_1$ = 596 – 1854 | | | | | | | | | |
| $W_1$ | 1148 | 21.4 | 1.00 | 0.81 | 0.83 | 4.44 | 1.30 | 4.67 | 1.27 |
| $W_2$ | 1138 | 20.9 | 0.98 | 0.79 | 0.80 | 4.47 | 1.29 | 4.61 | 1.25 |
| $W_3$ | 1144 | 20.7 | 0.97 | 0.78 | 0.80 | 4.42 | 1.29 | 4.57 | 1.24 |
| $W_4$ | 1150 | 20.5 | 0.97 | 0.77 | 0.79 | 4.40 | 1.29 | 4.54 | 1.24 |
| $W_5$ | 1156 | 20.2 | 0.96 | 0.77 | 0.78 | 4.43 | 1.30 | 4.56 | 1.25 |
| $W_6$ | 1165 | 20.1 | 0.95 | 0.76 | 0.77 | 4.35 | 1.29 | 4.56 | 1.26 |
| $W_7$ | 1176 | 19.7 | 0.95 | 0.75 | 0.76 | 4.36 | 1.31 | 4.57 | 1.27 |
| $W_8$ | 1190 | 19.3 | 0.94 | 0.74 | 0.75 | 4.33 | 1.31 | 4.54 | 1.28 |
| $W_9$ | 1209 | 19.2 | 0.94 | 0.73 | 0.75 | 4.26 | 1.31 | 4.47 | 1.28 |
| $W_{10}$ | 1229 | 19.0 | 0.94 | 0.73 | 0.75 | 4.20 | 1.31 | 4.42 | 1.29 |

* Mean for the W designated under stage.
† Coefficient of variation for the W designated under stage.
‡ Correlation (r) between the item designated in column heading and the W designated under stage.
§ Regression of $FCM_{10}$ and $FCM_8$ on the W designated under stage: by the linear equation, $FCM = a' + b'W$; and by the power equation, $FCM = aW^b$.

($FCM_8$ on $W_1$) is greater than for any one breed by itself. Associated with this greater slope is the greater correlation, 0.83, for all breeds together. The correlation between $W_1$ and $FCM_8$ is not an unqualified indication of development of the lactation function, for all breeds together can not be regarded as more highly developed than any one of the breeds by itself. It is merely that, in these samples, the breed of largest cows is more highly developed than any of the breeds of smaller cows.

*Regressions.* Of coordinate interest with the correlations of table 1, as above suggested, are the other regressions of milk-energy yield on live weight. They are expressed in two forms: the customary linear form, b′ in the equation $FCM = a' + b'W$; the curvilinear form, b, in the versatile and somewhat elusive power equation $FCM = aW^b$.

Because of the significance attached to the power equation in relating milk-energy yield to live weight by Kleiber and Mead (7) in a recent article in this Journal the b values of table 1 are of special interest. Following are singled out the b's corresponding to the r's singled out above:

| Breed | Value of b in $FCM = aW^b$ | |
|---|---|---|
| | $FCM_8$ and $W_1$ | $FCM_8$ and $W_{10}$ |
| Guernsey | 0.43 | 0.05 |
| Ayrshire | 0.84 | 0.34 |
| Jersey | 0.96 | 0.66 |
| Holstein | 1.01 | 0.83 |
| All 4 | 1.27 | 1.29 |

A general resemblance between the b's and r's is quite apparent.

There are, in fact, certain relations[3] between the three regressions, as follows:

$$b' = b(\overline{FCM}/\overline{W}) = r(SD_{FCM}/SD_W)$$
$$b = b'(\overline{W}/\overline{FCM}) = r(CV_{FCM}/CV_W)$$
$$r = b'(SD_W/SD_{FCM}) = b(CV_W/CV_{FCM})$$

If $\overline{FCM} = \overline{W} = SD_{FCM} = SD_W$ the three regressions are equal, $b' = b = r$. Which, if any, of the three is most significant from a biological point of view may be open to difference of opinion. Unit of measurement does not affect r or b, but does profoundly affect b′. Origin of measurement does not affect r or b′, but does profoundly affect b.

### *$FCM_s$ Proportional to $W_1$ Versus FCM Proportional to $W^{3/4}$*

Kleiber and Mead (7) argue that the "metabolic body size" of cows (and other animals) is proportional to the ¾ power of their live weight, and consequently as between cows milk-energy yield should be proportional to the ¾ power of live weight, b = 0.75. Brody (1) argues in much the same way but believes b = 0.70 (rather than 0.75). Still another view is that b = ⅔ in conformity with the idea that surface area of the animal is proportional to the ⅔ power of live weight.

In contrast to these complex fractional power concepts is the simple concept that milk-energy yield tends to be proportional to live weight, using $FCM_s$ and $W_1$ as criteria of yield and weight.

Can a fractional power theory such as the "¾ power rule" be validated by observed data on weight and yield? In table 1 the values of b range from −0.16 to 1.29 and it is possible to find a case which agrees with almost any positive fractional power theory one may choose.[4] It is futile to attempt to validate any postulated value of b in $FCM = aW^b$ from observations until FCM and particularly W are clearly and properly defined.

[3] Throughout this article b is computed as $b = b'(\overline{W}/\overline{FCM})$, or in case of $FCM/W = a'' + b''W$, as $b = 1 + b''(\overline{W}/\overline{FCM/W})$, where the overscore indicates the mean of the item overscored, and b′ or b″ is derived by least squares. The result closely approximates a least-squares solution of b, and for the present material use of the approximation is valid. Note: If a′ is positive $b < 1$; if a′ is negative $b > 1$; if a′ is zero $b = 1$.

[4] Fitting the equation, $FCM = aW^b$, may be regarded as a process of finding a value for b which makes $W^b$ proportional to FCM, as near as may be. It should be realized that $W^b$ is not a unit of weight. If we talk in terms of $W^b$ (*e.g.*, "kg. $^{3/4}$") we must not think in terms of weight. To be sure, it is conceivable that the weight of metabolically active tissue (excluding inactive tissue such as fill, perhaps bone, etc.) may be proportional to $W^{3/4}$, as Brody (1) argues. It is not likely that such is the case in cattle. Moulton (9) found the weight of protein (nitrogen) proportional to live weight in cattle, from which it may be assumed that the weight of active tissue is proportional to W and not $W^{3/4}$. In dairy cows it may be assumed that metabolic tempo and life span are independent of live weight within a breed, and probably between breeds. As between species (cow, goat, rat, etc.) metabolic tempo and life span are obviously very very different. The relation between W and FCM as between species must not be taken over as holding within dairy cows, with which latter this article is solely concerned.

Practical and biological reasons[5] have been mentioned above for the use of $W_1$ and $FCM_8$. Using $W_1$ and $FCM_8$ as criteria of weight and yield, the Holstein and Jersey records agree with the direct proportionality concept ($b = 1.01$ and $0.96$); the Ayrshire records agree fairly well ($b = 0.84$) and the Guernsey records are quite different ($b = 0.43$).

As with the correlations the differences between breeds with respect to b are probably merely differences in the samples at hand. It is suggested that as milking proclivity becomes more highly developed, under the influence of artificial selection the direct proportionality relation between $W_1$ and $FCM_8$ becomes more manifest. According to this view the Holstein cows are more highly developed dairy animals than the Guernsey cows, in these particular samples. This is quite in keeping with the interpretation offered in connection with the correlations above.

However, just as r is not an unqualified index of dairy development so b is subject to a similar limitation. When all four breeds are thrown together $b = 1.27$. This, of course, cannot signify that all breeds together are more highly developed than any one breed by itself. It is merely a consequence of the circumstance that the breed of largest cows, in these samples, yields more milk energy in proportion to live weight than the breeds of smaller cows. Other samples might easily show a different result.

On the interpretation that as dairy cows become highly developed $FCM_8$ tends to become proportional to $W_1$ a natural corollary is to set up $FCM_8/W_1$ as a measure of dairy development for the individual cow. If $FCM_8/W_1$ is measured at more than one lactation then an average of the measurements should afford a more reliable result than any one alone, provided $FCM_8/W_1$ does not change systematically and substantially with the sequence of lactations, or age of cow.

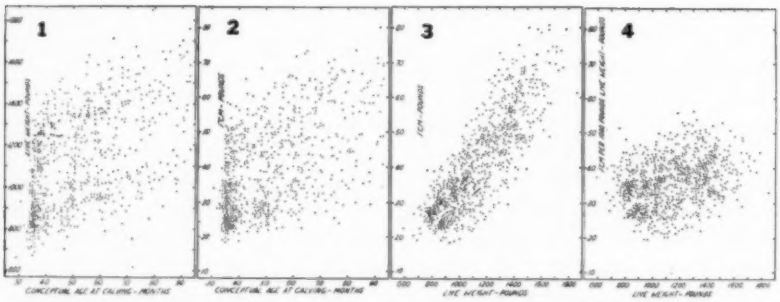
Thus far age of the cow has been ignored. Our next step is to introduce age into the analysis, dealing with $W_1$ and $FCM_8$. Hence forward the subscript may be omitted in W and in such case $W_1$ is understood; similarly for FCM in which case $FCM_8$ is understood.

### *Age, Live Weight and Milk-Energy Yield*

The relations between age, $W_1$ and $FCM_8$ are presented by individual lactations in figures 1, 2, 3, and 4. In figure 1, weight is plotted against age and in figure 2, FCM is plotted against age. The resemblance between the two graphs suggests that the drift of FCM with age may be due to the drift of weight with age.

In figure 3, FCM is plotted against weight and comparison of this graph with that of figure 2 shows that FCM is much more closely associated with

[5] Differences in $W_1$ are partly differences in fatness, at a time when fatness is in the nature of a food reserve. It is difficult to see any reason for putting this part of $W_1$ on a 3/4 power basis any more than for putting food consumption itself on a 3/4 power basis.




FIGS. 1–4. Showing individual lactations for the four breeds taken together.

FIG. 1. Live weight, $W_1$, plotted against conceptual age, A. A = months from date of birth to date of calving, dropping fractions of a month, and adding 10. The object of using conceptual age is to have substantially zero live weight at zero age. In order to approximate linear regression on age only lactations with $A < 94$ (birth age at calving less than 7 years) are included, n = 675. In the regression, $W = kA^e$, e = 0.34, r = 0.49.

FIG. 2. Milk-energy yield, $FCM_a$, plotted against conceptual age, A. Same lactations as figure 1. In the regression, $FCM = kA^e$, e = 0.55, r = 0.51.

FIG. 3. Milk-energy yield, $FCM_a$, plotted against live weight, $W_1$. Includes all ages (range in A = 25 – 174), n = 746. In the regression, $FCM = aW^b$, b = 1.27, r = 0.83.

FIG. 4. Milk-energy yield per 1000 pounds live weight, 1000 $FCM_a/W_1$, plotted against live weight, $W_1$. Same lactations as figure 3. r = 0.30.

weight than it is with age. In figure 4, FCM per unit weight is plotted against weight. The pronounced drift of FCM with weight (r = 0.83), shown in figure 3 largely disappears when we deal with FCM/W in figure 4, although a considerable positive drift remains (r = 0.30). This is due to the before-mentioned circumstance that the largest breed of cows has a higher FCM/W than any of the other breeds.

In figures 1–4 age effects are joint with weight and weight effects are joint with age. In figure 5 the effect of age and the effect of weight on yield

TABLE 2

*Effect of restricting age on b in the regression $FCM = aW^b$*

| Age* | Ayrshire | | Guernsey | | Holstein | | Jersey | | All 4 breeds | |
|---|---|---|---|---|---|---|---|---|---|---|
| | n | b | n | b | n | b | n | b | n | b |
| 2 | 58 | 0.41 | 39 | – 0.06 | 114 | 0.61 | 69 | 0.43 | 280 | 1.13 |
| 3 | 27 | 0.37 | 24 | – 0.46 | 68 | 0.39 | 43 | 0.43 | 162 | 1.15 |
| 4 | 21 | 0.81 | 10 | – 0.28 | 64 | 0.54 | 28 | 0.17 | 123 | 1.15 |
| 5, 6 | 16 | 0.83 | 3 | 0.80 | 71 | 0.55 | 20 | 1.14 | 110 | 1.14 |
| 7 | 9 | 1.61 | 1 | ..... | 50 | 0.87 | 11 | 2.00 | 71 | 1.26 |
| All† | 131 | 0.84 | 77 | 0.43 | 367 | 1.01 | 171 | 0.96 | 746 | 1.27 |
| None‡ | 131 | 0.65 | 77 | – 0.12 | 367 | 0.73 | 171 | 0.59 | 746 | 1.19 |

* Groups by birth age at calving in years. The 2 group includes all records under 3 years. The 7 group includes all records 7 years or over.

† No restriction of age.

‡ Age eliminated by the method of multiple regression.

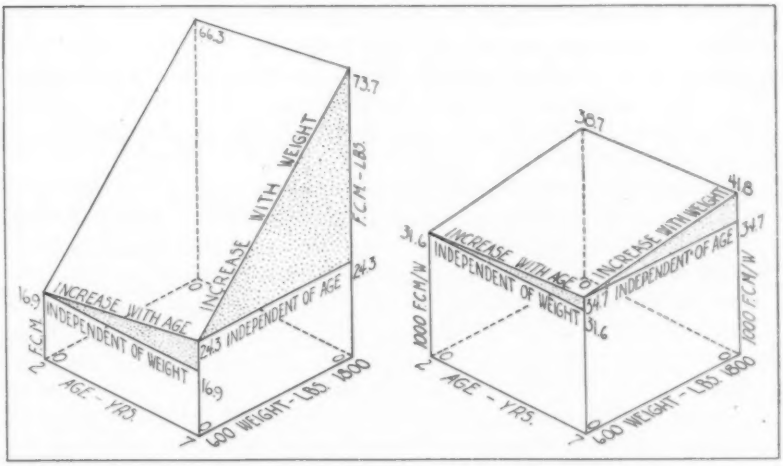



**FIG. 5.** (Left) Regression of milk-energy yield, $FCM_s$ on live weight, $W_1$ independent of age; and on age independent of live weight, $W_1$. Same lactations as figure 1.

**FIG. 6.** (Right) Regression of milk energy yield per unit live weight, 1000 FCM/$W_1$ on live weight, $W_1$, independent of age; and on age independent of live weight, $W_1$. Same lactations as figure 3.

are segregated. The dominant effect of weight as compared to age is clearly apparent, as was to be surmised from figures 1–3. Figure 6 presents a similar comparison dealing with FCM/W instead of FCM. The pronounced independent regressions of figure 5, dealing with FCM, largely disappear in figure 6, dealing with FCM/W.

TABLE 3

*Effect of restricting live weight on c in the regression $FCM = kA^c$, dealing with conceptual age at calving in months, A, and $A < 94$ (birth age at calving less than 7 years)*

| Weight group* | Ayrshire | | Guernsey | | Holstein | | Jersey | | All 4 breeds | |
|---|---|---|---|---|---|---|---|---|---|---|
| | n | c | n | c | n | c | n | c | n | c |
| 700 | ..... | ..... | ..... | ..... | ..... | ..... | 32 | 0.20 | 32 | 0.20 |
| 800 | 19 | 0.21 | 25 | 0.24 | ..... | ..... | 64 | 0.21 | 108 | 0.22 |
| 900 | 31 | 0.05 | 26 | 0.68 | ..... | ..... | 39 | 0.33 | 96 | 0.24 |
| 1000 | 42 | 0.18 | 25 | 0.59 | 18 | 0.34 | 25 | 0.62 | 110 | 0.14 |
| 1100 | 22 | 0.16 | ..... | ..... | 49 | 0.19 | ..... | ..... | 71 | 0.04 |
| 1200 | 8 | 1.02 | ..... | ..... | 65 | 0.35 | ..... | ..... | 73 | 0.33 |
| 1300 | ..... | ..... | ..... | ..... | 86 | 0.25 | ..... | ..... | 86 | 0.25 |
| 1400 | ..... | ..... | ..... | ..... | 59 | 0.36 | ..... | ..... | 59 | 0.36 |
| 1500 | ..... | ..... | ..... | ..... | 25 | 0.43 | ..... | ..... | 25 | 0.43 |
| 1600 | ..... | ..... | ..... | ..... | 15 | 0.01 | ..... | ..... | 15 | 0.01 |
| All | 122 | 0.26 | 76 | 0.49 | 317 | 0.40 | 160 | 0.39 | 675 | 0.55 |

* Lower group limit for W, except, in each breed class, the lowest weight group given includes also any lower W's and the highest weight group given includes also any higher W's.

The equation of the plane in figure 6 is $1000\ FCM/W = 26.32 + 0.0059W + 0.052A$. The means are $1000\ \overline{FCM/W} = 36.2$ and $\overline{W} = 1148$. From these statistics we can readily express FCM as a power function of live weight, $FCM = aW^b$, independent of age. We have, (see footnote 3) $b = 1 + 0.0059\ (1148/36.2) = 1.19$. In figure 3 we found $b = 1.27$ disregarding age, and now $b = 1.19$ with age eliminated.

For the different breeds b independent of age is: Ayrshire, $b = 1 - 0.0013\ (1031/33.3) = 0.65$; Guernsey, $b = 1 - 0.0357\ (960/30.6) = -0.12$; Holstein, $b = 1 - 0.0077\ (1348/39.1) = 0.73$; Jersey $b = 1 - 0.0159\ (894/34.5) = 0.59$. Within breed and independent of age b is less than unity.

For comparison with this multiple regression method of eliminating age table 2 has been prepared in which age is physically restricted to a limited range. In a general way the results agree with the multiple regression method. Considering the 367 Holstein records of all ages $b = 1.01$; eliminating age $b = 0.73$; for age groups b varies from 0.39 to 0.87. This means that, within age, regression of FCM on W is less than for all ages together. Consequently the statement that FCM tends to be proportional to W, or FCM/W is independent of W, needs to be qualified by not restricting age.

### *FCM/W Versus Age-Corrected FCM*

In table 2 age is restricted to show the regression of FCM on weight, $FCM = aW^b$, within age groups. In table 3 weight is restricted to show the regression of FCM on age, $FCM = kA^c$, within weight groups. So far as concerns FCM/W versus age-corrected FCM the point is that the c values of table 3 behave in roughly the same way as the b values of table 2.[6] In using FCM/W (as independent of weight) age distinctions are ignored and in using age-corrected FCM (as independent of age) live weight distinctions are ignored.

Previous results with D.H.I.A. records (5) indicated that the increase in yield ($FCM_s$) with age was entirely explainable by increase in live weight ($W_1$) with age. The present results do not quite agree with the earlier results and since the present data are of a higher order of accuracy than the D.H.I.A. data it is necessary to qualify the earlier conclusion (5).

While the present records show a statistically significant effect of age, independent of weight, on FCM/W the quantitative effect for all breeds together is not large, figure 6. A similar statement is true for each of the breeds, except Guernsey. The Guernsey records indicate that change in yield with age is entirely due to age and not at all to live weight. The Guernsey records cover a comparatively small range of age and weight,

[6] Comparisons of b and c in the equations, $FCM = aW^b$ and $FCM = kA^c$, are intended merely in a numerical sense. Possible physical implications of $W^b$ have been mentioned. Nothing of a similar nature is apparent for $A^c$ but it is still a good numerical description (for birth ages under 7 years). For the present data both b and c are regression coefficients (in terms of means) and nothing more.

tables 2 and 3, which may explain the divergent result. Another possibility is that the divergent result is associated with the comparatively low dairy development of the Guernsey sample: 1000 FCM/W, all ages, = 30.6 for Guernsey; 33.3 for Ayrshire, 34.5 for Jersey; 39.1 for Holstein.

One approach in a comparison of FCM/W and age-corrected FCM is to determine repeatability by means of intraclass correlation. The intraclass correlation with respect to a given item, X, is here derived by a modification of the method of Harris (6), adapting it to machine computation as follows:

Where punched cards are not utilized, record all the X's in the form of a table with each class (each cow in the present case) in a separate line. At one side of the table arrange three columns headed A, K, B. In each line separately compute and record: A = sum X; K = sum $X^0$ = item count; B = sum $X^2$. From the A's, K's and B's compute, $N = SK^2 - SK$ and

$$\text{intraclass correlation} = \frac{N(SA^2 - SB) - (SAK - SA)^2}{N(SBK - SB) - (SAK - SA)^2}.$$

Where punched cards are utilized, punch a separate card for each X with the value of X and its class identification number. Automatically machine punch each card with its $X^2$ by the method of interspersed master card gang punching.[7] Tabulate the A's, K's (= card count) and B's and apply in the formulas. Where the number of classes warrants the A's, K's and B's may be automatically punched into a new set of cards (summary cards) in the tabulating operation and these cards used in solution of the formulas.

This machinery permits the ready and precise solution of intraclass correlation, almost regardless of how large N may be. Other items ($X_2$, $X_3$, etc.) may be handled in a similar way on the same cards along with X (and in part simultaneously with X). Classes with only a single X do not affect the final result in the formulas and such classes may be either included or excluded as best fits into the whole program of analysis.

TABLE 4

*Cows with 2 or more lactations—intraclass correlation with respect to FCM, age-corrected FCM and FCM/W*

| Breed | Number of | | N | Intraclass r | | | 1% r* |
|---|---|---|---|---|---|---|---|
| | Cows | Lactations | | FCM | A–C FCM | FCM/W | |
| Ayrshire | 36 | 104 | 232 | 0.32 | 0.50 | 0.46 | 0.24 |
| Guernsey | 24 | 58 | 96 | 0.41 | 0.36 | 0.62 | 0.37 |
| Holstein | 103 | 323 | 888 | 0.33 | 0.38 | 0.42 | 0.12 |
| Jersey | 50 | 140 | 304 | 0.23 | 0.34 | 0.23 | 0.21 |
| All 4 | 213 | 625 | 1520 | 0.73 | 0.78 | 0.52 | 0.10 |

* From Snedecor (10) Table 7.2 taking n = N/2. N is the number of possible pairs but only N/2 pairs have individuality, each intraclass pair of individual observations being duplicated by mere reversal of order. This duplication is necessary to give an average of random combinations of any one lactation with any other one lactation of the same cow but does not reduce the sampling error.

Table 4 presents the intraclass correlations for FCM, age-corrected[8] FCM

[7] This is an invention of English and Bain. We are indebted to W. J. English, University of Illinois Tabulating Machines Office, for providing this facility.

[8] Corrections are by the official factors of the Holstein-Friesian Association for the Holstein records, and by the current factors of the Bureau of Dairy Industry for the other breeds.

and FCM/W. Use of intraclass correlation assumes that any one lactation is on a par with any other one lactation of the same cow, the sequence being immaterial. What meaning is to be attached to the correlations?

For illustration, the Guernsey correlations, table 4, are: FCM, 0.41; age-corrected FCM, 0.36; FCM/W, 0.62. FCM deals with actual milk-energy yields, all ages, all live weights. When FCM is corrected for age the correlation is decreased from 0.41 to 0.36; when FCM is divided by W the correlation is increased from 0.41 to 0.62. As noted, the records are related to age and not related to weight. It seems improbable that age correction makes the records less repeatable and dividing by W makes them more repeatable. The explanation is that the correlation is affected by both repeatability and by difference between cows, and of the two difference between cows is by far the more important. The probable situation is that age correction has not made the records less repeatable but has made the cows (that is, their records) less different; dividing by W has not made the records more repeatable but has made the cows more different.[9]

TABLE 5

*Full-year records*

| Item | Ayrshire | Guernsey | Holstein | Jersey | All 4 |
|---|---|---|---|---|---|
| Number of records: | | | | | |
| Others* | 107* | 62* | 151* | 126* | 446* |
| Full-year | 24 | 15 | 216 | 45 | 300 |
| Full-year/others, per cent | 22 | 24 | 143 | 36 | 67 |
| Means: | | | | | |
| 1000 $FCM_8$/W, others* | 32.9* | 29.7* | 37.3* | 33.7* | 34.2* |
| 1000 $FCM_8$/W | 35.1 | 34.3 | 40.3 | 36.8 | 39.1 |
| 1000 $FCM_{10}$/W | 33.1 | 32.7 | 38.6 | 34.9 | 37.3 |
| 1000 $FCM_{12}$/W | 30.5 | 31.4 | 36.7 | 33.3 | 35.5 |
| W, others* | 1028* | 960* | 1346* | 887* | 1086* |
| W | 1048 | 962 | 1351 | 916 | 1242 |
| Correlations: | | | | | |
| $FCM_8$/W and $FCM_{10}$/W | 0.986 | 0.996 | 0.986 | 0.975 | 0.972 |
| $FCM_8$/W and $FCM_{12}$/W | 0.962 | 0.981 | 0.989 | 0.938 | 0.957 |
| $FCM_{10}$/W and $FCM_{12}$/W | 0.992 | 0.993 | 0.980 | 0.973 | 0.971 |
| Multiple regressions: | | | | | |
| 1000 $FCM_8/W = a'' + b''W + dA$, $100b'' =$ | 1.48 | −3.16 | −0.63 | −1.41 | 0.44 |
| 1000 $FCM_{12}/W = a'' + b''W + dA$, $100b'' =$ | 1.24 | −3.43 | −0.82 | −0.81 | 0.40 |
| Regressions, independent of age: | | | | | |
| $FCM_8 = aW^b$, b = | 1.45 | 0.12 | 0.79 | 0.65 | 1.14 |
| $FCM_{12} = aW^b$, b = | 1.43 | −0.06 | 0.69 | 0.77 | 1.14 |
| Regressions, disregarding age: | | | | | |
| 1000 $FCM_8/W = a'' + b''W$, $100b'' =$ | 1.55 | −0.12 | 2.97 | 0.85 | 0.78 |
| 1000 $FCM_{12}/W = a'' + b''W$, $100b'' =$ | 1.22 | −0.53 | 0.04 | 0.83 | 0.67 |
| $FCM_8 = aW^b$, b = | 1.47 | 0.96 | 1.10 | 1.21 | 1.25 |
| $FCM_{12} = aW^b$, b = | 1.43 | 0.84 | 1.01 | 1.19 | 1.24 |

* Records other than lactations with a full 365 days in milk.

[9] The ratios of between-cows variance to within-cow variance are: FCM, 2.63; age-corrected FCM, 2.33; FCM/W, 5.33; (degrees of freedom 23 and 34, 1% F = 2.40). As

Intraclass correlation (or for that matter interclass correlation, first lactation and second lactation, etc.) is not an unqualified measure of the effect of such manipulations as age correction on repeatability (although table 4 is not without value for further scrutiny). An ideal situation would be to have a sufficient sample, all individuals genetically alike, in milking proclivity, and then find a measure of yield which makes the intraclass correlation zero.

FCM/W and age-corrected FCM represent two different philosophies. Age-corrected FCM deals with the organism as a whole, without distinction as to size. FCM/W deals with the average cell of the organism (assuming number of cells proportional to live weight) without distinction as to age. The essential question is can we learn more about the biology of milk production by dealing with live weight and yield per unit live weight than we can by dealing with yield per cow? If we have two herds, one of 8 cows and the other of 16 similar cows, there is little question about dealing with yield per cow rather than yield per herd. If we have two cows, one with 8 hundredweight of cells and the other with 16 hundredweight of similar cells why not deal with yield per unit weight rather than yield per cow? The herd is an aggregate of cows. The cow is an aggregate of cells. The cell rather than the herd or the cow is the comparable biological unit.

### *Full-Year Records*

Table 5 presents certain data pertaining to those lactations in which the cow was still in milk at the end of 365 days. Attention is directed to two items. $FCM_s/W$ is materially higher for these records than for others, indicating superior cows or superior lactations or both. Disregarding age the values of b in $FCM_s = aW^b$ are: Guernsey, 0.96; Holstein, 1.10; Jersey, 1.21; Ayrshire, 1.43; all four breeds, 1.25. Accepting the idea that these are superior cows the results support the foregoing conclusion that as the lactation function becomes more highly developed the direct proportionality relation between live weight ($W_1$) and milk-energy yield ($FCM_s$) becomes more manifest.

It may be noted that in the Guernsey records, disregarding age, FCM is proportional to $W^{0.96}$, compared to $W^{0.43}$ for all Guernsey records in table 1. Independent of age, however, FCM is proportional to $W^{0.12}$ or practically independent of live weight. The 365-day Guernsey records retain the peculiarity that FCM is little affected by live weight, independent of age, or even negatively correlated (Table 2). This is interpreted as a sample peculiarity rather than a breed peculiarity.

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an extension of illustration, it is not likely that yield is affected by the day of the month on which a cow is born. But multiplying FCM by this birthday (1 to 31) increases the intraclass correlation from 0.41 to 0.91. This is not to be interpreted as making the records more repeatable but rather as making the cows more different (between-cows variance/within-cow variance = 32.49).

TABLE 6

*Records by breed (A = Ayrshire, G = Guernsey, H = Holstein, J = Jersey) by calendar year in which the cow calved and by times milked daily for a given year the first line gives the average 1000 FCM/W and the second line gives the number of records*

| Year Calved | 2× | | | | 3× | | | | 4× | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | G | H | J | A | G | H | J | A | G | H | J |
| 1921 | ..... | ..... | ..... | 27.9 | 34.8 | 25.3 | 33.4 | 37.0 | ..... | ..... | 43.3 | ..... |
| | | | | 1 | 2 | 1 | 6 | 3 | | | 5 | |
| 1922 | ..... | ..... | ..... | ..... | 28.7 | ..... | 30.1 | 32.7 | 39.7 | ..... | 40.1 | ..... |
| | | | | | 3 | | 2 | 3 | 1 | | 11 | |
| 1923 | ..... | ..... | ..... | ..... | 30.4 | 28.6 | 23.7 | 35.5 | ..... | ..... | 40.9 | 46.7 |
| | | | | | 1 | 1 | 1 | 3 | | | 10 | 2 |
| 1924 | ..... | ..... | ..... | ..... | 27.3 | 31.3 | ..... | 27.8 | 39.5 | ..... | 39.4 | 35.8 |
| | | | | | 2 | 3 | | 2 | 1 | | 17 | 1 |
| 1925 | ..... | ..... | ..... | ..... | 29.6 | ..... | ..... | 28.9 | 38.5 | ..... | 38.5 | 40.5 |
| | | | | | 2 | | | 5 | 3 | | 20 | 5 |
| 1926 | ..... | ..... | ..... | 34.1 | 28.7 | ..... | 31.0 | 34.6 | 32.4 | ..... | 39.0 | 32.3 |
| | | | | 1 | 3 | | 2 | 3 | 2 | | 19 | 5 |
| 1927 | 28.2 | 30.4 | ..... | 30.9 | ..... | ..... | ..... | ..... | ..... | ..... | 39.4 | 39.5 |
| | 2 | 1 | | 4 | | | | | | | 20 | 4 |
| 1928 | 23.5 | ..... | ..... | 30.1 | 33.6 | 21.9 | ..... | 34.7 | ..... | 40.7 | 41.3 | 36.3 |
| | 2 | | | 1 | 3 | 1 | | 6 | | 2 | 17 | 7 |
| 1929 | ..... | ..... | ..... | ..... | 30.5 | 29.7 | ..... | 32.3 | 33.7 | 42.8 | 37.1 | 44.6 |
| | | | | | 6 | 2 | | 7 | 5 | 2 | 19 | 5 |
| 1930 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 30.9 | 37.6 | 39.8 | 32.8 |
| | | | | | | | | | 10 | 2 | 21 | 7 |
| 1931 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 34.8 | 32.7 | 39.1 | 37.6 |
| | | | | | | | | | 12 | 7 | 16 | 8 |
| 1932 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 33.5 | 31.3 | 36.7 | 32.3 |
| | | | | | | | | | 6 | 9 | 17 | 13 |
| 1933 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 34.0 | 32.2 | 39.2 | 29.7 |
| | | | | | | | | | 8 | 7 | 26 | 9 |
| 1934 | ..... | ..... | ..... | ..... | 29.7 | 27.6 | ..... | 28.9 | 31.6 | 31.7 | 41.1 | 34.4 |
| | | | | | 2 | 2 | | 1 | 8 | 6 | 20 | 6 |
| 1935 | ..... | ..... | ..... | ..... | 29.7 | 26.3 | 31.1 | 32.2 | 39.3 | 40.5 | 38.1 | ..... |
| | | | | | 5 | 4 | 7 | 9 | 2 | 1 | 13 | |
| 1936 | ..... | ..... | ..... | ..... | 30.5 | 24.7 | 34.1 | 33.6 | ..... | ..... | 40.0 | ..... |
| | | | | | 6 | 6 | 1 | 8 | | | 16 | |
| 1937 | 25.5 | 20.9 | ..... | 27.3 | 32.9 | 33.1 | 32.5 | 33.5 | 41.3 | ..... | 40.8 | ..... |
| | 1 | 4 | | 1 | 7 | 5 | 7 | 8 | 2 | | 17 | |
| 1938 | ..... | 23.3 | ..... | ..... | 33.4 | 28.8 | 36.3 | 35.8 | ..... | ..... | 41.7 | ..... |
| | | 1 | | | 7 | 6 | 7 | 12 | | | 19 | |
| 1939 | ..... | ..... | ..... | ..... | 37.4 | 33.3 | 39.9 | 36.0 | ..... | ..... | 43.5 | ..... |
| | | | | | 13 | 4 | 21 | 18 | | | 1 | |
| 1940 | ..... | ..... | ..... | ..... | 41.9 | ..... | 44.7 | 39.5 | ..... | ..... | ..... | ..... |
| | | | | | 4 | | 9 | 3 | | | | |
| All | 25.8 | 22.9 | ..... | 30.4 | 33.2 | 28.8 | 36.8 | 34.1 | 34.0 | 33.6 | 39.6 | 35.5 |
| | 5 | 6 | | 8 | 66 | 35 | 63 | 91 | 60 | 36 | 304 | 72 |
| Reg.* | −0.10 | −0.86 | ..... | −0.15 | +0.41 | +0.10 | +0.51 | +0.18 | −0.97 | −1.27 | +0.05 | −0.89 |

* Regression, change in 1000 FCM/W for each advance of one year in time.

### *Frequency of Milking and Time Trends*

Table 6 presents the FCM/W records classified by frequency of milking and year in which the cow calved, for each of the breeds.

*Frequency of milking.* During 1930–34 all cows were milked four times daily. Since 1938 all cows have been milked three times daily. Throughout the intent in the herd management has been to give every cow opportunity to express herself in milk yield. While there are material differences in FCM/W as between 2, 3, and 4 milkings per day we have not deemed it advisable to make corrections for frequency of milking. There is too much uncertainty about what part of the differences in FCM/W is due to differences in times milked and what part is due to differences in the cows themselves.[10] For the present material it is assumed to be safer to ignore frequency of milking than to make corrections for it, or to subdivide the material by frequency of milking.

*Time trends.* The present records cover a period of 20 years and a natural question relates to possible time trends in the data. Linear regression considered for the period represented is shown in the bottom line of table 6. The regressions are part positive and part negative. They appear small but this may be deceptive. For example, in Holstein 4× the regression is +.05. This indicates in 20 years an increase of 1 pound FCM per 1000 pounds live weight per day. Such an increase, at the existing level of yield (1000 FCM/W = 39.6) is not exactly negligible in its biological aspects. Holstein 3× records show a corresponding regression of +.51, or an increase in 20 years of 10 pounds FCM per 1000 pounds live weight per day. This regression is materially influenced by the 1939 and 1940 data which include cows previously milked four times daily, that is inherently high FCM/W cows. This occurrence at the extreme end of the regression line produces a marked effect on the slope of the line.

Analysis of variance of the records without regard to frequency of milking indicates there are no statistically significant differences in FCM/W as between years. The ratios of between-years variance to within-year variance are: Ayrshire, 1.31; Guernsey, 1.03; Holstein, 1.34; Jersey, 1.69. In all cases the ratios are below the 5 per cent level of significance. If frequency of milking is ignored assuming that it, like amount and kind of feed, is a matter of management to permit expression of the milk-giving function, the foregoing comparisons, embracing a 20-year period, are not upset by time trends in the data.

### *Practical Applications*

It has been shown that live weight is related to milk energy yield, and most closely when live weight is measured within 31 days after calving ($W_1$)

[10] Frequency-of-milking comparisons should consider whether the cows yield more milk because they are milked more frequently, or whether the cows are milked more frequently because they yield more milk.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reg.* | −0.10 | −0.86 | ..... | −0.15 | +0.41 | +0.10 | +0.51 | +0.18 | −0.97 | −1.27 | +0.05 | −0.89 |

* Regression, change in 1000 FCM/W for each advance of one year in time.

rather than at a later stage of lactation. For many purposes $W_1$ at each lactation is all that is needed. For such purposes the use of $W_1$ exclusively would be advantageous. Where live weights at other stages of the reproductive cycle are required, as in feeding experiments, $W_1$ should be included. In making up balanced groups with respect to live weight $W_1$ should be used if milk yield is an important part of the investigation. Reports of the results of such investigations should include the data on $W_1$.

The use of $FCM_8/W_1$ has not been extensive enough as yet to establish its value beyond question. It is a factual system of measuring milk yield which appears to be practically independent of age of cow and disregarding age, as practically independent of live weight, in good dairy cows. If this appearance proves to be fact the practical applications are many and too plain to require detailed enumeration. What is needed is an extensive and accurate determination of $W_1$ and $FCM_8$ in the field, that is in good commercial dairy herds. We believe the present evidence is sufficient to settle the use of $W_1$ in each lactation in preference to live weight at any later stage of that reproductive cycle, thus simplifying a plan of field investigation to that extent.

Once an adequate criterion of lactation performance of the dairy cow is established a practical application of the intraclass correlation (which can be easily computed by the method outlined) is its use for an individual herd. Say that $FCM_8/W_1$ is such a criterion. Then the objective is to secure a uniformity of the cows in the herd such that the intraclass correlation with respect to FCM/W is zero. This brings to an end improvement by selection within that stock. But by the same token disimprovement is also eliminated. If average FCM/W is at a satisfactory level the advantage of such a stock is evident. For example, in feeding trials, cows could be taken as they come if results are to be measured in terms of FCM/W. The present Jersey herd comes near to qualifying for this zero correlation (Table 4) but the level of FCM/W (1000 FCM/W = 34.5) is not as high as may be reasonably demanded. The corresponding Holstein level is 39.1 and we believe a similar level, regardless of breed as such, may be set up as a reasonable standard.

## SUMMARY

This article deals with 746 lactations of Ayrshire, Guernsey, Holstein and Jersey cows in the Nebraska Station dairy herd. Live weight at each lactation is considered at 10 stages: within 31 days after calving, $W_1$; one month later, $W_2$; and so on to 9 months later, $W_{10}$. Principal attention is given to yield for the first eight months of lactation, expressed as milk-energy yield in terms of pounds of 4 per cent milk per day, designated FCM.

FCM is more closely related to $W_1$ than to live weight at any later stage of the same lactation. A single live weight determination in each lactation

is sufficient for many purposes and for such purposes the exclusive use of live weight measured within 31 days after calving is recommended, in the interest of uniformity and biological significance.

$FCM/W_1$ is so little affected by age that age corrections are unnecessary. Disregarding age, $FCM/W_1$ is practically independent of live weight or FCM tends to be proportional to $W_1$. This direct proportionality relationship becomes more manifest the more the lactation function is developed, that is, the higher the level of $FCM/W_1$.

It is suggested that $FCM/W_1$ may be used as a criterion of dairy development and that an ideal is to secure a stock in which the intraclass correlation between lactations of the same cow with respect to $FCM/W_1$ is zero; provided, however, that $FCM/W_1$ is at a satisfactorily high level.

Expressing milk-energy yield as a power function of live weight, $FCM = aW^b$, disregarding age, the value of b decreases more or less uniformly from $W_1$ to $W_{10}$. For example, in the Jersey records, $b = 0.96$ for $W_1$; 0.75 for $W_4$; and 0.66 for $W_{10}$. It is futile to try to validate any postulated value of b, such as $\frac{2}{3}$ in conformity with surface area concepts, unless the stage of lactation at which live weight is measured is clearly and properly defined.

The correlation between live weight ($W_1$) and milk-energy yield in the present records is greatest for all breeds thrown together, $r = 0.83$. The corresponding power equation relationship shows milk-energy yield is proportional to the 1.27 power of live weight.

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# THE EFFECT OF ULTRA-VIOLET IRRADIATION ON THE VITAMIN A, CAROTENE, AND RIBOFLAVIN CONTENT OF MILK*

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Carotene, vitamin A, vitamin $B_1$, and riboflavin are destroyed or inactivated partially or completely by prolonged exposure to ultra-violet light (4, 6, 7, 10). These observations assume importance in view of the fact that considerable quantities of milk are exposed to ultra-violet irradiation daily in the production of vitamin D milk. Several investigators (1, 3, 13) have reported no destruction of carotene, vitamin A, and vitamin $B_1$ when milk was irradiated to produce approximately 135 U.S.P. units of vitamin D per quart. However, longer exposures to ultra-violet rays as used to produce the 400-unit milk recently developed warrant a reinvestigation of this problem.

## EXPERIMENTAL

This study consisted of two series of experiments on irradiation and the vitamin content of cow's milk, Series 1 being concerned with vitamin $B_1$ and Series 2 with carotene, vitamin A, and riboflavin. In Series 1, the milk used was not pasteurized and was prepared specially for this study.[1] In Series 2, five different lots of milk were examined. Lots I and II were taken directly from the plant of a large Chicago milk distributor as they were prepared for the market. Lots III and IV were obtained from the same source as the milk used in Series 1. All of the irradiated milk was assayed biologically for vitamin D and was found to contain at least 400 U.S.P. units per quart.[2]

*Series 1—Vitamin $B_1$.* The effect of irradiation on the vitamin $B_1$ content of milk was determined by the rat-growth technique. Thirty-five male rats, 21 days of age and averaging 47 grams in weight were depleted of their vitamin $B_1$ stores by feeding them a vitamin $B_1$-low diet composed of autoclaved corn starch 66, water-extracted casein 18, autoclaved yeast 8, Wesson salts 4, agar 2, and cod liver oil 2 parts, respectively. To minimize the development of rancidity, the rations were mixed twice weekly and kept in a refrigerator between feedings. The rats were weighed weekly during the first two weeks, daily the next four weeks and weekly the final two weeks of the experiment.

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[1] We are indebted to Dr. K. G. Weckel of the Department of Dairy Industry of the University of Wisconsin, Madison, for this supply of milk.

[2] We are indebted to Dr. H. T. Scott of the Wisconsin Alumni Research Foundation for the vitamin D assays.

TABLE 1

*The effect of ultra-violet irradiation on the vitamin $B_1$ content of milk*

| Time on supplement | Average weight of rats* on | | |
|---|---|---|---|
| | Untreated milk† | Irradiated milk† | 3γ thiamin/rat daily |
| *weeks* | *gm.* | *gm.* | *gm.* |
| 0 | 71 | 71 | 68 |
| 1 | 84 | 81 | 77 |
| 3 | 102 | 102 | 103 |
| 5 | 122 | 122 | 129 |

* These rats were fed a vitamin $B_1$-low basal ration in addition. There were twelve rats in the groups on milk and five in the group on vitamin $B_1$.

† 10 cc. per rat daily.

After three weeks on the vitamin $B_1$-low ration, the rats had stopped growing and were either losing slightly in weight or practically maintaining themselves. At this stage, twenty-four rats were divided into two groups so that the average weight and the range in weight were approximately the same in each group. Each morning, in addition to the basal ration, every rat was given 10 cc. of milk, either untreated or irradiated. In addition to these groups on milk, a third group of five rats was given the basal ration plus three micrograms of crystalline vitamin $B_1$ per rat daily. Each morning, the vitamin $B_1$ was fed by dropper as a solution in 10 per cent ethyl alcohol.

The average gain in weight per rat during the 5-week period was 51 grams in the group which received untreated milk as well as in the group which received irradiated milk (table 1). Furthermore, the rate of growth was similar in both groups throughout the entire experiment. These results,

TABLE 2

*The effect of ultra-violet irradiation on the carotene, vitamin A, and riboflavin content of milk*

| Date | Lot No.* | Sample No. | Treatment | Vitamin A potency/gm. butterfat | | Riboflavin/cc. milk |
|---|---|---|---|---|---|---|
| | | | | Carotene | Vitamin A | |
| | | | | γ | γ | γ |
| 8/10/39 | I | 1 | Untreated | 8.0 | 13.9 | 2.5 |
| | | 2 | Irradiated | 8.2 | 13.6 | 2.5 |
| 1/27/40 | II | 1 | Untreated | 2.5 | 7.8 | 2.4 |
| | | 2 | Irradiated | 2.7 | 7.5 | 2.4 |
| 2/17/40 | III | 1 | Untreated | 2.6 | 8.9 | 2.2 |
| | | 2 | Irradiated | 2.5 | 8.5 | 2.1 |
| 2/17/40 | IV | 1 | Untreated | 2.3 | 7.7 | 2.1 |
| | | 2 | Irradiated | 2.3 | 7.9 | 2.1 |
| 2/17/40 | V | 1 | Untreated | 2.1 | 6.8 | 2.1 |
| | | 2 | Irradiated | 2.1 | 6.8 | 2.0 |

* Lots I and II were market milks and Lots III–V were experimental milks.

therefore, demonstrate that irradiation of milk with the resultant production of 400 U.S.P. units of vitamin D per quart did not reduce the vitamin $B_1$ content.

The data on the rats on crystalline vitamin $B_1$ indicate that the milk contained approximately 3 micrograms of vitamin $B_1$ per 10 cc. This value is in the same range as that reported by Halliday and Deuel (8) who found cow's milk to contain approximately 4.5 micrograms of thiamin per 10 cc. In addition, in a review of recent literature, Halliday and Deuel showed that numerous investigators have found cow's milk to contain between 2 and 3 micrograms of vitamin $B_1$ per 10 cc.

*Series 2—Carotene, vitamin A, and riboflavin.* Carotene and vitamin A were extracted from the fluid milk by the method of Olson, Hegsted, and Peterson (12) after which they were measured spectrophotometrically (2). The value $E\ {}^{1\%}_{1\ cm.}\ 328\ m\mu = 1600$ was used in all the calculations of vitamin A. The microbiological method of Snell and Strong (14) was used to estimate the amount of riboflavin in the milk.

As with vitamin $B_1$, ultra-violet irradiation had no effect on the carotene, vitamin A, or riboflavin content of milk (table 2). In all five lots the amount of these vitamins was practically the same in the irradiated milk as in the untreated milk. The values for riboflavin are in agreement with those reported by recent investigators (9, 11). The lower carotene and vitamin A values of the winter milk as compared with those of the summer milk were due to normal seasonal variations (5).

## SUMMARY

Experimental and market milks irradiated with ultra-violet light to produce 400 U.S.P. units of vitamin D per quart were not reduced in vitamin $B_1$, carotene, vitamin A, or riboflavin content.

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# ABSTRACTS OF LITERATURE

## BOOK REVIEWS

274. **Milk and Milk Products.** C. H. Eckles, W. B. Combs, and H. Macy. McGraw-Hill Book Co., Inc., New York. 413 pages, illustrated, $3.50.

Teachers of the introductory course in dairying will be glad to learn of the Third Edition of Milk and Milk Products. Progress in dairy science is rapid and scientific principles are quickly adopted by the industry. To be of greatest usefulness text books must keep abreast of this progress.

In the third edition of Milk and Milk Products the authors have attempted to include some of the facts and principles of recent establishment and their practical application. Teachers and students should welcome this introduction to a rapidly expanding subject matter field. T.S.S.

275. **Manual of Veterinary Bacteriology. 4th Ed.** Raymond A. Kelser and Harry W. Schoening. Williams and Wilkins Co., Baltimore. 1943.

This, the fourth edition of what has long been a standard textbook of veterinary bacteriology, is a distinct improvement over the previous editions. It will be noted that Dr. Schoening, Chief, Pathological Division, Bureau of Animal Industry, is coauthor of this edition, and many of the chapters have been revised by men especially trained in their respective fields.

Those familiar with other editions will find a rearrangement in the order of presentation of organisms. The chapter on the *Salmonella* has been revised considerably and the antigenic structure of each species is given. Better balance in the space alloted each genus and specie has been attained. The discussion on staining methods and on preservation, culture and staining of protozoa has been enlarged. Nomenclature follows the latest edition on Bergey's Manual, followed by the most important synonyms. A much enlarged section on viruses affecting humans and domestic and laboratory animals is a distinct improvement. As in previous editions, sections on milk and water examination, hematology, and preparation of veterinary biological products are included and brought up to date.

One thing possibly lacking in a textbook of veterinary bacteriology is a discussion of disinfection, antiseptics, and disinfectants. S.A.F.

276. **Advances in Enzymology and Related Subjects of Biochemistry, Vol. III.** Edited by F. F. Nord and C. H. Werkman. 11 sections, plus author and subject index, and cumulative index of volumes

I, II, and III. 407 pages. Interscience Publishers, Inc., 215 fourth Ave, New York, N. Y. $5.50.

This is the third of three volumes on Enzymology, the two previous issues having been reviewed in JOUR. DAIRY SCI. *26:* A31. Feb., 1943. As in previous issues, this volume is a compilation of papers by authorities in the field of enzymology. The sections or chapters are conveniently arranged in textbook manner, each with an outline of contents which greatly facilitates its use. Each is well outlined to enable orientation of the reader in the subject. Several of the sections will be of immediate interest to workers in the dairy sciences; these are: Effect of Temperature on Enzyme Kinetics by Sizer; an excellently illustrated discussion on X-Rays and the Stoichemistry of the Proteins by Astbury; the Chemistry and Biochemistry of Pantothenic Acid by Williams, and of Biotin by Hofmann; the Role of Micro Organisms and Enzymes in Wine Making by Cruess. Other sections include Chromosomes and Nucleoproteins; Chemistry of Glycogen; Verdoperoxidase; Mechanisms, and Intermediary Stages, of Carbohydrate Metabolism; and Recent Progress in Tumor Enzymology. The convenient manner in which the book is arranged and the inclusion of several subjects excellently reviewed and of interest to research workers in dairy laboratories make this third of the volumes of value to the research laboratory.

K.G.W.

## BACTERIOLOGY

**277. Research on the Technique of the Coliform Test.** H. BARKWORTH, South-Eastern Agr. Col., Wye, Kent. Proc. Soc. Agr. Bact. (Gr. Britain). p. 14. 1942.

Thirty lactose tubes were inoculated with 1-ml. quantities of milk and 30 tubes with 1-ml. quantities of water at the standard rate of 0.5 organisms per ml. In the first 7 trials the milk was inoculated and the tests completed immediately after milking, and there was a highly significant difference. This might have been due to the bactericidal action of milk, and therefore milk was stored for 24 hours at both 40° F. and 72° F. before inoculation and making the tests. In 29 trials using stored milk, the percentage of positives was 19% for milk stored at 72° F., 23% for milk stored at 40° F. and 27% for water. It is thus established that the presumptive coliform test when applied to milk gives an under-estimation of the population.

M.W.Y.

**278. Pyrex Suspensions in Turbidimetric and Colorimetric Determinations. Standards of Comparison for Bacterial Suspensions and in the Resazurin Test.** FRANCIS J. HALLINAN, Div. Lab. and Res., N. Y. State Dept. Health, Albany, N. Y. Amer. Jour. Pub. Health, *33,* 137–140. 1943.

Methods are given for the preparation of Pyrex glass suspensions as

standards of turbidity. Pyrex suspensions in colored media have been substituted for suspensions of barium sulfate in the standardization of bacterial suspensions and have been employed experimentally in the resazurin and resazurin-rennet tests for the grading of milk. The glass suspensions closely resemble bacterial suspensions in appearance, settle slowly, and remain stable longer than those of barium sulfate. In the resazurin test, Pyrex suspensions in colored media have the advantage of being directly reproducible from readily available materials. Standardization in terms of an accepted color-recording system and in relation to milk-quality is suggested. Pyrex standards have been found to be stable for at least one year.

M.W.Y.

**279. Milk-Borne Outbreaks Due to Serologically Typed Hemolytic Streptococci.** THOMAS D. DUBLIN, EVELYN F. H. ROGERS, JAMES E. PERKINS, AND FRED W. GRAVES, N. Y. State Dept. Health, Albany, N. Y. Amer. Jour. Pub. Health, *33*, 157–166. 1943.

In the case of nine milk-borne outbreaks of hemolytic streptococcus throat infections in New York State, a different Griffith type was encountered in each outbreak with the exception of three outbreaks due to Type 3.

The epidemiological study of a recent outbreak of 44 cases of Type B hemolytic streptococcus throat infection occurring in a small rural community is described in detail. The infection was found to be transmitted by raw milk secured at a local cheese plant.

Although the cheese plant handled milk representing the output of 6,069 cows, it is believed that the cow responsible for the outbreak was located by means of Breed smear examination of cans of milk received at the plant, and subsequent veterinary and bacteriological follow-up of suspected herds.

All cheese processed and stored in the plant between April 5, the date of last shipment, and April 22, when pasteurization of milk was begun, was embargoed. Samples were taken from cheese processed on each day during the interval and although large numbers of beta hemolytic streptococci were readily recovered from them, none of the many strains studied proved to be members of Lancefield's Group A. Because it was impossible, nevertheless, to state that strains of hemolytic streptococci pathogenic for man were not present in the cheese, it was treated by a process in which it was heated to a temperature of over 170° F. for several minutes, insuring destruction of any pathogenic microorganisms which might be present. M.W.Y.

**280. Coliform Organisms Found in Private Wells.** E. H. GARRARD, Ont. Agr. Col., Guelph, Canada. Canad. Jour. Pub. Health, *34*, No. 2: 87. 1943.

Examinations were made of 1400 samples of water from farm and school wells. In addition a few samples from ponds, streams and dairy storage tanks were tested. Out of this total, 174 showed gas in lactose broth of

which 126 proved positive in lactose brilliant green bile broth. Additional tests ("IMViC" reactions, fermentation of sucrose, production of $H_2S$, liquifaction of gelatin, and fermentation of lactose at 44° C.) indicated that 62% of the organisms belonged to types other than faecal *Esch. coli*. Members of the *Aer. aerogenes* and Intermediate groups should, however, be also considered indicative of faecal pollution. O.R.I.

## BREEDING

**281. Vererbunsstudien in Michviehbestande des Versuchsgutes Friedrichsort.** H. BÜNGER, Prussian Dairy Res. Inst., Keil. Züchtungsk, *17*, 2 and 4: 33–56; 109–129. 1942.

An analysis of the progeny and breeding value of three bulls each used three years in an experimental herd of about 20 to 30 cows, where no females were introduced after the herd was established. Actual yields of daughters and dams are compared first, then these are expressed relative to the contemporary herd average. The actual yields can be seriously misleading but expressing them relative to the herd average is found not to be entirely satisfactory either, since the average genetic composition of the herd itself changes as time passes. Comparison with the herd average is more essential for milk yields than for fat percentages, since the latter are less influenced by general changes in weather or management.

The regression of daughters on dams is quite noticeable for fat percentage, although not expressed specifically in those terms. Separate comparisons are made in those cases where two or all three bulls have daughters out of the same dams. This is not quite a diallel crossing comparison, since the daughters of the two (or three) bulls were not contemporary. The first 180 days of the lactation is enough for determining fat percentage, provided the bull has at least ten daughters. More than two lactations per cow are necessary for establishing with any assurance the milk producing ability of the cows. Arrangement of the daughter-dam comparisons as a curve with the highest dams at the left and the lowest at the right and the size of the record as the ordinate is thought superior to the heredity grid for presenting the facts in an easily comprehensible form. German conditions make an increase in the fat much more important than an increase in yield of milk, since the supply of protein available for feeding is the most important limitation on production. The author says that yield of milk and per cent of fat are independent of each other, but in his table 15 he shows that on the average the test declines about 0.011 per cent for each 100 kilograms increase in milk production. J.L.L.

**282. Breeds of Dairy Cattle.** E. E. ORMISTON, Univ. Ill. Exten. Ser. Circ. 543. Dec., 1942.

An attractive bulletin giving in considerable detail the characteristics

and origin of the five major breeds of dairy cattle in the United States, viz.: Ayrshire, Brown Swiss, Guernsey, Holstein and Jersey. J.G.A.

**283. Die Bedeutung des Rassenässigen Aufbaus unserer Rinderbestände für die Rohstoffversorgung der Lederwirtschaft.** W. GRASSMANN AND J. TRUPKE, Inst. Leather Res., Dresden. Züchtungsk, *17*, No. 3: 73–81. 1942.

An account of differences among breeds of cattle in the suitability of hides for the leather industry. In order of preference the breeds are named as follows: Höhenfleckvieh, Limburger, Pinzgauer, Gelbes und lichtes Höhenvieh, Sudentenfleckvieh, Rotes Höhenvieh, Rot-und Braunblässen, Murnau-Werdenfelser, Graubraunes Höhenvieh, Angler, Rotbuntes Tieflandrind, Shorthorn, and Schwarzbuntes Tieflandrind.

Some descriptions and reasons for these statements are included but little detailed evidence or proof is given. J.L.L.

**284. Freshening Date Changes of Cows in Iowa Dairy Herd Improvement Associations.** C. Y. CANNON AND E. N. HANSEN, Iowa State Col., Ames, Iowa. Jour. Anim. Sci., *2*, No. 2: 112–117. May, 1943.

Iowa Dairy Herd Improvement Association records covering sixteen years (1926–1941) with a total of 153,610 cows with known calving dates and calving records of the dairy cows in the Iowa State College herd were used in this study.

The average percentage distribution of freshening dates of cows among Iowa Dairy Herd Improvement Association cows was for winter, spring, summer and fall, 30, 19.8, 14.1 and 36.1% respectively. In the Iowa State College herd where no apparent effort was made to freshen cows for the first time in any one season, the distribution of freshening dates for winter, spring, summer and fall was 26.7, 23.3, 21.6 and 28.4% respectively. On the other hand, 157 Iowa State College cows that calved for the first time in the fall had subsequent calvings that had a similar distribution to that among Iowa Dairy Herd Improvement Association cows.

The data indicate that Iowa dairymen have made an effort to freshen their cows in the fall, but calving intervals longer than twelve months cause some calving dates to shift to other seasons. Economic factors other than high milk yields probably hinder any shifting of cows whose calving dates occur in other seasons back to fall calving. C.F.H.

## BUTTER

**285. Comparative Studies in the Prevention of Wood Taint, Toppiness and Primrose Colour of Storage Butter.** T. L. FORSTER AND R. W. BROWN, Univ. Man., Winnipeg, Manitoba. Sci. Agr., *23*, No. 6: 342. 1943.

Results of two experiments are reported in which various types of boxes

and box liners were compared as to their ability to prevent surface deterioration of creamery butter during storage. Among the factors studied were the following: spruce and poplar as box materials; paraffin; casein-formalin and no treatment as box interior coverings; ordinary parchment; avenized parchment and four types of aluminum foil-parchment as box liners; combinations of the above factors. The butter was stored for 8 to 9½ months at 0° F. or lower. Several surfaces of each sample were scored by three graders and the resulting scores were treated statistically.

Poplar had a greater tendency to produce wood taint although this could be overcome by the use of foil-parchment liners. The casein-formalin treatment was an important aid in preventing wood taint. All types of foil-parchment liners gave excellent protection against primrose color and almost complete protection against wood taint. Only one type proved to be very satisfactory in preventing undesirable surface flavors. There was evidence that the adhesives used in some of the other varieties of foil-parchment liners produced objectionable flavors. Avenized parchment was quite a satisfactory liner except that it did not prevent primrose color. O.R.I.

## CHEESE

**286. A Note on the Recovery of Bacteriophage.** A. A. Nichols and J. Z. Wolf, Natl. Inst. Res. in Dairying, Univ. Reading. Proc. Soc. Agr. Bact. (Gr. Britain). p. 19. 1942.

Phage was demonstrated in cheese 3 weeks and 3½ months old, made from a starter which had phaged. An extract was prepared by shaking 10 g. of cheese with 20 ml. of ¼ strength Ringer's solution in a stoppered flask containing glass beads. The extract was then lightly centrifuged, filtered through a Seitz filter and tested against phage-susceptible strains which were components of the starter originally used in the making. Phage was thus demonstrated in cheese made in 7 different vats using 3 starters in 2 distant localities. In one batch of cheese made from raw milk decimal dilutions of the filtered extract showed that after 3½ months' ripening phage was present in quantities of cheese as small as 0.00005 gram. M.W.Y.

**287. Coliform Organisms in Cheddar Cheese.** E. L. Crossley, Aplin and Barrett, Ltd., Yeovil, Somerset. Proc. Soc. Agr. Bact. (Gr. Britain). p. 16. 1942.

Cheese were made at 3 factories from pasteurized milk. "Flash" pasteurized milk was commonly free from coliform organisms, but infection sometimes resulted from cooler or pipe line contamination. A variety of types was found. After cutting the curd, coliform contamination seemed almost inevitable.

The predominance of *B. coli* I increased as storage lengthened. Periodic examinations of cheese originally containing mixtures of *B. coli* I and *B.*

*aerogenes* I, or *B. coli* I and *B. coli* II, revealed *B. coli* I as the sole survivor after four months' storage, but *B. coli* I was isolated from 2 cheese after 12 months' ripening.

Curd samples at milling ranged in coliform count from 75,000 to 20,000,000 per gram. Cheese at 2 months yielded counts varying from 10,000 to 220,000 per gram. M.W.Y.

**288. Storing Cottage Cheese in Brine.** E. L. Fouts, T. R. Freeman, and John Faustini, Fla. Agr. Expt. Sta., Gainesville. South. Dairy Prod. Jour., *33*, No. 4: 10. Apr., 1943.

Experiments were conducted at the Florida Experiment Station Dairy Products Laboratory in which cottage cheese curd was stored at 35° F. and 45° F. in two, four and six per cent salt solutions.

The curd was made by the short-time method, using 0.67 ml. of rennet extract to 100 gallons skim milk and washed twice, the second time in water at 40° F. Two pounds of drained curd was placed in each of 48 half-gallon glass jars. The curd in 16 jars each was covered with two per cent, four per cent, and six per cent brines. Half of the jars containing each of the brines were stored at 35° F. and the remainder at 45° F.

Mold was present at the end of two months in all samples stored at 45° F. and a fermented flavor had developed. This temperature was satisfactory for a maximum period of one month.

Bitter flavor was noted in a relatively small number held at 35° F. Curd stored at this temperature lacked freshness but was of good quality after being stored two months. It showed some evidence of fermentation at the end of three months.

Curd stored in six per cent brine was too salty. Lots packed in four per cent brine did not require additional salt and were not too salty.

Containers which will not corrode should be selected. F.W.B.

## CHEMISTRY

**289. Photometric Determination of Reduced and Total Ascorbic Acid.** Melvin Hochberg, Daniel Melnick, and Bernard L. Oser, Food Res. Lab., Inc., Long Island City, N. Y. Jour. Indus. and Engin. Chem., Analyt. Ed., *15*, No. 3: 182. Mar., 1943.

Reduced and total ascorbic acid in biological materials, including milk products, have been determined by a modification of published photometric methods based on the rate of decolorization of the dye 2,6-dichlorophenol-indophenol. A nomogram has been presented to facilitate the estimation of the ascorbic acid concentration from the residual photometric densities of the dye at the end of 5 and 10 seconds of reaction. The reduction of the dye by the vitamin was found to be a reaction of the second order; the rate constant was calculated for 25° C. and pH 3.5. The photometric procedure

has a much greater degree of specificity than the visual titration, and allows determinations to be made on extracts containing small amounts of ascorbic acid, even in the presence of relatively large amounts of other substances which reduce the dye. B.H.W.

**290. Studies Relating to the Use of Lactobacillus Casei in Microbiological Assay.** A. E. LIGHT AND MIRIAME F. CLARKE, Burroughs Wellcome and Co., Tuckahoe, N. Y. Jour. Biol. Chem., *147*, No. 3: 739. 1943.

It is generally considered that the amount of acid or degree of turbidity developed by *L. casei* during an incubation period is proportional to the amount of riboflavin, pantothenic acid, or certain other media vitamins in the various media which are used. It has also been shown, that under certain conditions, however, more than twice the amount of acid formerly regarded as maximal can be produced. The purpose of this report was to investigate the media and study the characteristics of the dose-response curve obtained with graded amounts of pantothenic acid. An improved medium is described, in which yeast extract is omitted, and an increase in glucose, asparagine and other nutrients made. A longer and steeper dose-response is obtained which enables greater accuracy in the determination.

NOTE: In Jour. Biol. Chem., *147*, No. 2: 485. 1943, a brief report in a letter to the editor cites the successful use of *Neurospora crassa* in a microbiological assay for p-aminobenzoic acid, and in a similar transmissal to the editor reported in Jour. Biol. Chem., *146*, No. 1: 277. 1942, *Aerobacter suboxydans* is also stated to respond in growth to the presence of the factor. K.G.W.

**291. A Lactobacillus Assay Method for p-Aminobenzoic Acid.** J. C. LEWIS, Western Regional Res. Lab. Bur. Agr. Chem. and Engin., U.S.D.A., Albany, Calif. Jour. Biol. Chem., *146*, No. 2: 441. 1942.

This method, based on the growth factor activity of para-aminobenzoic acid for *Lactobacillus arabinosus* 17–5 is reported to be rapid and accurate. Reproducibility of results and check of added quantities of the factor are cited. The sensitivity range is estimated to be 0.15 to 0.5 millimicrogram of p-amino benzoic acid. Complete details of the medium and method of assay are presented. The p-amino benzoic acid content of skim milk is reported: Sample 1, fresh, 0.0040; slightly sour, 0.011; sour, 0.019. Sample 2, fresh, 0.0046; sour, 0.0075, parts per million. Attention is called to the occurrence of inactive p-amino benzoic acid in certain biological materials, which can be activated by alkaline hydrolysis. K.G.W.

**292. Determination of Calcium by Precipitation with Picrolonic Acid and Polarographic Measurement of the Residual Picrolonic Acid.**

GUNTHER COHN AND I. M. KOLTHOFF, School of Chem., Univ. Minn., St. Paul. Jour. Biol. Chem., *147*, No. 3: 705. 1943.

The calcium in concentration ranges of from 0.001 to 0.01 M is precipitated as calcium pierolonate with an excess of standard pierolonic acid solution. The excess of reagent is determined polarographically without filtering the solutions, thus overcoming the difficulty of incomplete removal of imperfectly formed precipitate crystals, or with their solubility. The method is accurate within 1 to 2%. Good results are obtained when the solution also contains relatively large amounts of Na, K, $NH_4$, Mg sulfate and phosphate. K.G.W.

**293. Inactivation of Biotin by Rancid Fats.** P. L. PAVCEK AND G. M. SHULL, Dept. Biochem., Univ. Wis., Madison. Jour. Biol. Chem., *146*, No. 2: 351. 1942.

The development of oxidative rancidity in fats and oils is known to be destructive also of certain of the vitamins, such as A, D, and E, in certain products. In this study one of the B vitamins, biotin, was inactivated in vitro by a rancidified ration (containing also cod liver oil and butterfat) and oxidized ethyl linolate. Vitamin E added to the linolate partially stabilized the destruction of biotin, changing the rate from 96 to 40% after 48 hours incubation. K.G.W.

**294. Antioxidant Activity in Sources of the B Vitamins.** PAUL GYÖRGY AND R. TOMARELLI, School of Med., Western Reserve Univ., Cleveland, Ohio. Jour. Biol. Chem., *147*, No. 3: 515. 1943.

Decolorization of a ration substrate containing corn starch and butter yellow (the carcinogenic N, N-dimethylaminoazobenzene unrelated to the natural colorings used for butter)-linoleic acid mixture to which were added various antioxidants was investigated. The grains corn, oats, and wheat, rice bran extract, and Avenex exhibited high antioxidant properties. Other antioxidants of the sources of the B complex were yeast, yeast extract, liver extract, molasses, and milk sugar residue. The antioxidants in rice, rice bran extract, Avenex and yeast were found to be heat-labile (autoclaving 120° C. for 30 minutes). Of all the known B vitamins, only p-aminobenzoic acid proved significantly antioxygenic in these experiments. K.G.W.

## CONCENTRATED AND DRY MILK; BY-PRODUCTS

**295. Present Trends and Future Outlook. The Dry Milk Industry.** MERRILL O. MAUGHN. Amer. Dry Milk Inst. South. Dairy Prod. Jour., *33*, No. 4: 4. Apr., 1943.

Defatted dry milk solids is the greatest undeveloped reservoir of essential food in the country today. Two-thirds of the food value of the original

milk is lost when butter alone is made. Dr. Russell Wilder estimates that only 12% of the available solids-not-fat is used as human food. Four billion pounds of these dry milk solids could be manufactured in America.

The present name of "dry skim milk" is derogatory and misleading. The government is being asked to give this product a respectable name in return for the immense quantities being supplied for war use.

The volume of dry milk solids manufactured has increased from 16,000,000 pounds in 1916 to 475,000,000 pounds in 1941. This branch of the dairy industry is larger than the cheese industry (on a dry basis), nearly as large as the evaporated milk branch and uses more products of the cow than the ice cream industry.

Most dehydrated foods seem to be here to stay. Sound economics demands the wise use of all separated milk. Drying seems to be the best solution. Use in bread, sausage, ice cream and candy offers substantial markets.

F.W.B.

## DISEASE

**296. Establishment of Infection with Trichomonas foetus in Bulls by Experimental Exposure.** DATUS M. HAMMOND AND DAVID E. BARTLETT, Beltsville Research Center, Washington, D. C. Amer. Jour. Vet. Res., *4*, No. 10: 61. Jan., 1943.

Two bulls bred to 4 infected females each did not become infected nor did one bull bred to an uninfected female immediately after service to an infected bull. In a second series of experiments, two bulls were infected after one exposure to trichomonas infection by inserting pledgets of cotton soaked in infected vaginal washings into the prepuce. In four others, trichomoniasis could not be established by repeated exposure with the same methods or by wrapping the penis in cotton soaked in vaginal washings from infected females. No evidence of inflammation was seen in the two successful infections. Individual resistance to trichomoniasis is suggested.

S.A.F.

**297. Field Observations on the Control of Contagious Mastitis.** P. S. WATTS, Hannah Dairy Res. Inst., Ayr. Proc. Soc. Agr. Bact. (Gr. Britain). p. 35. 1942.

An attempt has been made to control contagious mastitis in 65 herds containing 5000 cows. Quarter samples have been taken personally every two months for three years and 180,000 samples have been examined by the plate test. Since this test is impracticable for wide use, Edwards' liquid medium and McKenzie's thallium acetate broth have been investigated. Of the 1776 samples in Edwards' medium 408 (23%) gave deposits and were plated. 115 were *Streptococcus agalactiae* and 293 were not. With the

thallium broth 100 (25%) of the 395 samples tested gave deposits, 43 being true positives and 57 false. In both cases, approximately 60% of the true positive samples were correctly diagnosed.

The work has revealed the importance of secondary factors in raising the mastitis infection rate. If the rate is below 15% it is not considered that any great change in management is required, but if over this, then there is usually some fundamental cause other than the mere presence of *S. agalactiae*. Higher rates of infection may, however, be due to a large proportion of old cows. Segregation is of no value in the more heavily infected herds.

The most important secondary factor so far established is the milking machine. An analysis of 45,000 tests showed that the mean infection rate in herds milked by one machine was 14% and in herds milked by another 40%. Two examples are given where the substitution of one machine for the other led to a progressive drop in the infection rate from 89% to 79% respectively to 45% and 42% during a period of 6 months. A machine should milk at 13 lb. pressure or less, at about 38 pulsations per minute, be light in construction and easily disinfected. An example is given of where a certain type of teat cup with an old liner was still heavily contaminated with *S. agalactiae* after 40 seconds in hypochlorite solution (1400 parts available chlorine per million).

It is contended that by proper precautions and attention to secondary factors and by the sale of all old, heavily infected animals the incidence of mastitis has been considerably reduced in many of the herds under control. M.W.Y.

**298. A Note on the Use of a Composite Medium for the Detection of *Streptococcus agalactiae*.** D. A. SOULIDES, Univ. Reading. Proc. Soc. Agr. Bact. (Gr. Britain). p. 36. 1942.

Peptone (Evans) 10 g., "yeastrel" 3 g., and sodium chloride 2.5 g. are dissolved in 900 ml. warm distilled water. The solution is adjusted to pH 7.2, steamed 1 hour and filtered through "chardin" paper. Mannitol 5 g., aesculin 1 g. and sodium hippurate 10 g. are dissolved in 100 ml. distilled water and adjusted to pH 7.0. The two solutions and 10 ml. Andrade's indicator are then mixed. The medium is tubed in 2.5-ml. quantities and sterilized by autoclaving at 10 pounds for 10 minutes or by intermittent steaming for 30 minutes on each of 3 days.

After incubation for 48 hours at 37° C. all tubes showing a pink color are discarded. From each of the remainder 0.5 ml. is withdrawn into a clean test tube for a catalase test, and one loopful is dried on a slide and stained with crystal violet. To catalase negative tubes 0.4–0.5 ml. 7% aqueous ferric chloride is added. Hippurate positive cultures show a brick red precipitate which does not settle in 30 min. Aesculin positive strains give

a green-black color. Hippurate negative, aesculin negative cultures exhibit a clear deep brown solution.

Twenty-eight authentic strains of milk streptococci of 12 different species and 80 strains isolated in the laboratory from milk were used. *S. agalactiae* is distinguished from all other streptococci except occasional strains of *S. thermophilus* by a brick-red precipitate. M.W.Y.

**299. Prevention and Treatment of Infectious Calf Scours with "Sulfasuxidine" Succinylsulfathiazole.** HARRY W. HERRIOTT, Hershey, Pa. Jour. Amer. Vet. Med. Assn., *102*, No. 793: 261. Apr., 1943.

One gram of "sulfasuxidine" succinylsulfathiazole per kg. body weight, divided into four daily doses and continued three to four days, was effective in treating infectious calf scours. Treated calves were from herds where death occurred 24–36 hours after birth as well as from herds where the disease ran a more chronic course. S.A.F.

**300. The Value of the Cell Content and Electrical Conductivity of Milk as Criteria of Bovine Mastitis.** J. F. MALCOLM, C. W. KING, AND M. M. CAMPBELL. West of Scotland Agr. Col. Proc. Soc. Agr. Bact. (Gr. Britain). p. 30. 1942.

In this experiment there were two series of composite samples from individual cows, the first of 582 specimens and the second 168. There were also 532 individual quarter specimens. If a standard of 500,000 cells per ml. were employed for the differentiation of infected from non-infected specimens, then the cell count gave the same result as the culture test with 86% of the first series of composite samples, with over 90% of the second series of composite samples and with 85% of the individual quarter specimens.

To determine the diagnostic value of the conductivity and certain other tests, another experiment was carried out with the bulk milk of single cows and individual quarter specimens. The pH value was not a reliable indication of mastitis. Assuming for the electrical conductivity a standard of $49.0 \times 10^{-4}$ mhos and for the cell count a standard of 500,000 cells per ml. to differentiate infected from non-infected specimens, then 72% of the bulk specimens were correcty diagnosed by the conductivity test and 78% by the cell count. M.W.Y.

**301. Supplemental Report on the Treatment of Streptococcic Mastitis with Tyrothricin.** F. E. MARTIN, West Chester, Pa. Jour. Amer. Vet. Med. Assn., *102*, No. 793: 267. Apr., 1943.

A 50% mineral oil emulsion containing 1.5 mg. of tyrothricin per cc. was used in treating 37 quarters of 18 cows shedding long chain streptococci.

24 quarters were freed of the organism and nine of 18 cows were cured of the infection with an average of 7.7 treatments per quarter. All quarters rendered free of the infection remained so for from 2–8 months. Infected cows remained in the herd and were milked last. S.A.F.

**302. Brucellosis of Cattle.** R. GRAHAM AND J. SAMPSON. Univ. Ill. Ext. Ser. Cir. 544. Jan., 1943.

A popluar treatise employing the question and answer method on the nature, spread, losses from, diagnosis of, and control of brucellosis (Bang's disease). The federal-state program of control as it applies to the state of Illinois is explained in detail. J.G.A.

**303. The Effect of *Brucella Abortus* on the Bovine Udder and Its Secretion.** A. C. EMMINGER AND O. W. SCHALM, Univ. Calif., Berkeley. Amer. Jour. Vet. Res., *4*, No. 10: 100. Jan., 1943.

The quality of the milk from *Brucella abortus* infected quarters was not significantly different from the normal product. Visible particles were not observed in the foremilk, and the pH, chloride content, leucocyte count, and saprophytic bacterial count were well within normal limits.

A careful examination of the entire parenchyma of each infected quarter failed to reveal gross lesions. Histopathological changes were observed, however, in 17 out of 19 quarters that had harbored *Br. abortus* for periods varying from sixteen to 324 days. These consisted of an exudation of neutrophiles into the alveolar lumen, associated with fatty degeneration of the alveolar epithelium with a tendency toward desquamation of epithelial cells. More commonly, however, the microscopic pathology was characterized by a dense accumulation of lymphocytes and plasma cells in the interalveolar tissues. Epithelioid cells and giant cells were found in some instances. In the larger inflammatory foci, proliferation of the connective tissue elements occurred. In some instances, the supramammary lymph nodes also contained histopathological changes S.A.F.

**304. Sulfaguanidine in the Treatment of Infectious Enteritis in Swine.** H. C. H. KERNKAMP AND M. H. ROEPKE, Univ. Minn., St. Paul. Amer. Jour. Vet. Res., *4*, No. 10. Jan., 1943.

Studies were conducted on the efficiency of various doses of the drug, as compared to untreated controls, on field cases, on blood, fecal and urine concentrations, and on the toxicity to normal swine. Except in chronic cases or those complicated by secondary conditions, doses of from 0.75 to 1.5 gms. per 10 pounds body weight for from six to eight days were beneficial. In order to obtain high fecal concentrations as early as possible, the initial dose was usually double subsequent doses. Feces approached normal

about the fourth day. A considerable amount of the drug was absorbed as shown by relatively high concentrations excreted in the urine. It was considered probable that animals which recover as a result of sulfaguanidine therapy do not possess significant immunity and treatment should be supplemented with sanitary practices.

Double the maximum dose given above produced toxic symptoms within five days with muscular incoordination and increased white cell count. Except for nephrosis, postmortem findings were negative. S.A.F.

**305. Effect of Injections of Novoxil on the Bovine Udder Infected with Mastitis Streptococci.** G. R. SPENCER AND B. A. BEACH, Univ. Wis., Madison. Amer. Jour. Vet. Res., *4*, No. 10: 45. Jan., 1943.

Novoxil treatment of 3 quarters of 2 cows infected with *Streptococcus agalactiae* produced an acute clinical inflammation with secretions containing abnormally large amounts of catalase and chlorides. The number of streptococci eliminated was reduced markedly, but a few were found in the secretions of all 3 quarters sixteen days later, just before the cows were slaughtered. Postmortem gross and histopathologic examinations disclosed acute inflammatory changes which were more severe in the 2 quarters clinically abnormal before treatment than in the quarter which was giving normal milk prior to the injections. Injection of 21 dry quarters of 6 infected cows resulted in the elimination of the infection in 11 quarters, with very little or no inflammation produced. S.A.F.

**306. Studies on Johne's Disease: Reactions to Johnin in Sensitized Guinea Pigs.** H. KONST AND E. A. WATSON, Hull, Quebec. Amer. Jour. Vet. Res., *4*, No. 10: 34. Jan., 1943.

The sensitizing effect of cultures of Johne's bacillus in various vehicles, when injected into guinea pigs by various routes, showed that an intraperitoneal injection forty-eight hours after an injection of a suspension of calcium phosphate by the same route gave the most favorable results. Guinea pigs thus sensitized were used successfully for potency-determinations of purified protein derivatives of johnin in intradermal tests similar to those used in standardization of tuberculin. S.A.F.

## FEEDS AND FEEDING

**307. New Developments in Dairy Cattle Feeding.** W. E. KRAUSS, Ohio Agr. Expt. Sta., Wooster, Ohio. Internatl. Assoc. Milk Dealers, Assoc. Bul., *35*, No. 11: 159–162. Feb., 1943.

Ohio Agricultural Experiment Station trials involving 128 cows on 100–110 day periods showed no difference in milk production at various fat levels in the ration ranging from 2.7 to 4.9%. Thus apparently no need exists

for raising the fat percentage of the grain mixture made up of the usual dairy feeds. Grass silage seems to offer the best hope for maintaining the carotene and vitamin A content of milk during the winter season. Using more alfalfa, timothy hay and less corn silage has permitted the use of grain and at the same time maintained a good level of production. Four ounces of yeast containing at least 1,000,000 units of vitamin D fed daily seemed to be of benefit in reducing the number of cows suffering from milk fever. Of the first 75 freshenings 12% of the cows receiving irradiated yeast and 29% of the controls developed milk fever. In the case of those animals which had a previous history of milk fever the percentages were 20 in the yeast fed group and 73 in the controls. Success is reported limiting the milk ration of calves to 350 pounds of whole milk fed during the first 6 or 7 weeks. E.F.G.

**308. Further Studies on Riboflavin and Thiamine in the Rumen Content of Cattle. II.** C. H. Hunt, E. W. Burroughs, R. M. Bethke, A. F. Schalk and P. Gerlaugh, Ohio Agr. Expt. Sta., Wooster, Ohio. Jour. Nutr., *25*, No. 3: 207–216. Mar., 1943.

Steers with rumen fistula were used to determine the effects on the synthesis of riboflavin and thiamine in the rumen of (a) whole versus ground corn, (b) varying proportions of hay and corn, and (c) increasing amounts of fairly pure carbohydrates in a partially synthetic ration.

The data show that riboflavin is synthesized in the rumen of the steer when a ration containing corn, alfalfa hay, and a protein supplement is fed. When corn was omitted from the alfalfa hay-protein supplement rations there was no apparent synthesis of riboflavin. As the amount of corn in the ration increased, there was a corresponding increase in the riboflavin content of the ingesta. The riboflavin content of the ingesta was also higher when ground corn was fed in place of an equal weight of whole corn. The results also show an increase in riboflavin synthesis with a corresponding increase in carbohydrates.

There was no evidence from the data presented that thiamine was synthesized in the rumen. C.F.H.

**309. A Note on the Effect on the Kidneys and Livers of Feeding Urea to Steers Fattening in Dry Lot and on Pasture.** S. H. Work, C. J. Hamre, L. A. Henke, and L. E. Harris, Univ. Hawaii. Jour. Anim. Sci., *2*, No. 2: 166–169. May, 1943.

Three lots of steers fed on dry lot and 5 lots fed pasture were used. Lots 2 and 3 of the dry lot fed steers received 0.88 and 2.29% of the dry matter as urea. While lots 2 and 3 of the pasture fed steers received 0.97 and 1.91% of the dry matter as urea. Histiological studies of the livers and kidneys were made. The levels of urea feeding used in this investiga-

tion did not result in liver or kidney damage. In view of the reports by other investigators that 2.8% of the dry matter of the ration caused kidney damage, the authors suggested that the harmful level of urea feeding for cattle may be between 2.29 and 2.8% of the dry matter of the ration.

C.F.H.

**310. Studies on the Metabolism of Zinc with the Aid of Its Radioactive Isotope. I. The Excretion of Administered Zinc in Urine and Feces.** G. E. SHELINE, I. L. CAHIKOFF, H. B. JONES, AND M. L. MONTGOMERY, Dept. Physiol., Univ. Calif. Med. School, Berkeley, and Div. Surgery, Univ. Calif. Med. School, San Francisco. Jour. Biol. Chem., *147*, No. 2: 409. 1943.

Investigations which have been made in the distribution of administered zinc in the body have involved the introduction into the animal of relatively large amounts of the salt of this metal. In this investigation the excretion of zinc was studied in the dog and mouse by use of the radioactive istotope, which permitted intravenous administration of minute amounts of the salt of the metal, amounts that were negligible when compared with the total amounts of zinc already in the animal. A large fraction of the Zn appears in the feces. In the mouse 50% of the Zn injected was eliminated via gastrointestinal tract in 170 hours, in the dog about 25% at the end of 12 to 14 days. Labelled Zn was continuously excreted in the urine of both mice and dogs during these periods, to the extent of 2 and 1.2–4.7%, respectively. The results are interpreted to mean that a large fraction of the body Zn is eliminated by way of the gastrointestinal tract. K.G.W.

**311. Metabolism of a Paraffin.** DEWITT STETTON, JR., Dept. Biochem, Columbia Univ., New York City. Jour. Biol. Chem., *147*, No. 2: 327. 1943.

It has been generally believed that aliphatic saturated hydrocarbons were completely unabsorbed and metabollically completely inert. Evidence to the contrary does exist; it having been shown as early as in 1933 and 1934 that n-hexadecane was not only absorbed but was catabolized to give undetermined products. The purpose of this study was to determine whether normal aliphatic hydrocarbons may be oxidized, in the animal body, to fatty acids. Deuterio hexadecane was mixed in a ration and this fed ad libitum to growing rats until 200 gm. were consumed. Study of the anatomical portions of the animal was made to determine the fate of the hydrocarbon. At the level of feeding employed, 83 mg. per rat per day, hexadecane is very efficiently absorbed from the gastrointestinal tract and partially deposited as such in the tissue lipids. Much of the absorbed hexadecane was found to have been oxidized to fatty acid in the body, apparently largely in the liver. K.G.W.

**312. Dairy Cattle Feeding and Management.** E. E. ANDERSON, New Mex. Col. Agr. and Mechanic Arts. New Mexico Col. Agr. and Mechanic Arts Cir. 175. Dec., 1942.

As the title indicates information is given in some detail on almost all phases of dairy husbandry. J.G.A.

**313. Establishing and Improving Permanent Pastures in North Carolina.** W. W. WOODHOUSE, JR., AND R. L. LOVVORN, N. C. Expt. Sta. Bul. 338. Dec., 1942.

Data are presented on liming and fertilization, adaptation of pasture plants, seeding practices, and pasture management. Eight steps listed as necessary in obtaining pastures are: (1) Legumes are the first essential for good pastures. (2) Lime, phosphate, and potash are necessary for the satisfactory growth of legumes. (3) Poor soils should be improved with lime, phosphate, potash and lespedeza before grasses are seeded. (4) Seedings must be made on a shallow, firm seedbed. (5) Vegetative mulches are very helpful in preventing drying and crusting of seedbeds on eroded, clay soils. (6) Dallis grass, Bermuda grass, orchard grass, Kentucky bluegrass, lespedeza and white clover are the best adapted pasture plants for North Carolina. Their individual requirements are discussed in this publication. (7) Good permanent sods cannot be maintained without the control of weeds and brush. (8) Overgrazing should be avoided. This can be accomplished by providing supplemental pastures during the late fall, winter and early spring, and during drought periods at any time of the year. J.G.A.

## FOOD VALUE OF DAIRY PRODUCTS

**314. Need for Observations of Growth in Appraising Adequacy of Nutrition in Childhood.** HAROLD C. STUART, Amer. Jour. Dis. Children, *65*, No. 2: 320–325. 1943.

The author of this paper urges that the growth of children be measured in connection with nutritional surveys and that evidences of faulty growth be given more consideration in appraisals of nutrition. Some of the difficulties of making growth studies of children are pointed out. But it is suggested that such studies be made to correlate any relation between what children eat and how they grow, for it is not known what rate of growth is desirable for best health or physical fitness. French and Spanish children were, on the average, considerably shorter than American children, and this is of interest in view of habitually low consumption of milk and other animal foods, both prior and since the war. While there is no proof as to the part played by nutrition in producing differences found to exist between these European groups and American children there is good reason to believe from studies of nutrition and growth in animals that these suggestive associations in human beings have some real significance and that the na-

tional stature might be as dependent on national food habits as racial potentialities of growth. R.K.W.

**315. Calcium and Phosphorus Requirements of Premature Infants.** HELEN R. BENJAMIN, HARRY R. GORDON AND ELEANOR MORPLES. Amer. Jour. Dis. Children, *65*, No. 3: 412–425. 1943.

A study was made of the retentions of calcium and phosphorus by three premature infants receiving a diet of human milk and by three fed a cow's milk preparation. The infants retained a greater portion of the intake of both minerals than is reported for full term infants. The daily calcium intake on the human milk diet was 56 mg. and on the cow's milk diet was 165 mg. The infants retained on the average 71% of the calcium intake from cow's milk and 45% from human milk. Possibly lack of phosphorus in human milk acted as a limiting factor in retention of calcium.

Mineral retention with a diet of human milk supplemented with vitamin D was inadequate to meet lowest calcium requirements which were arbitrarily selected after reviewing literature. Retentions by the premature infants with the cow's milk diet, on the other hand, were sufficient to insure normal calcification of the bony structure at one year of age. From the standpoint of skeletal formation it is concluded that for premature infants human milk is not the best food unless supplemented with both calcium and phosphorus. R.K.W.

**316. Digestibility of Some Animal and Vegetable Fats.** R. HOAGLAND AND G. G. SNIDER. Bur. Anim. Indus., U.S.D.A., Beltsville, Md. Jour. Nutr., *25*, No. 3: 295–302. Mar., 1943.

The true coefficients of digestibility of butterfat, oleo stock (beef fat rendered at about 68° C.), mutton tallow, coconut butter, soybean oil, corn oil and coconut oil were determined with young rats at 5% and 15% of the diet. The metabolic fat was estimated by placing the rats on a fat free diet and determining the crude fat in the feces.

When the diets contained 5% fat, the following digestive coefficients were obtained: coconut oil 98.9, soybean oil 98.5, corn oil 97.5, butterfat 88.3, mutton tallow, 74.6, oleo stock 74, and cocoa butter 63.3%. When the diets contained 15% fat, the digestive coefficients were as follows: soybean oil 98.3, corn oil 98.3, coconut oil 96.5, butterfat, 90.7, oleo stock 86.7, mutton tallow 84.8 and cocoa butter 81.6%.

There was no consistent relationship between the melting points of the fats and their digestive coefficients. C.F.H.

**317. The Availability of the Calcium of Some New Zealand Vegetables.** JOAN KELLY, Univ. of Otago, New Zealand. Jour. Nutr., *25*, No. 3: 303–308. Mar., 1943.

The availability of the calcium of several vegetables was compared with

that of the calcium of milk using growing rats. The calcium intake and body gains of the animals in the various groups were equalized. The calcium retention was determined by carcass analysis after a period of experimental feeding averaging nine weeks.

Using the availability of milk as 100, the availability of beet greens, swede turnip, savory cabbage, and parsnip was 46, 87, 93 and 88 respectively.

The author concluded that the calcium of milk is better utilized than the calcium of the vegetables tested. C.F.H.

318. **The Effect of Dietary Calcium, Phosphorus, and Vitamin D on the Utilization of Iron. II. The Effect of Vitamin D on Body Iron and Hemoglobin Production.** IRVIN FUHR AND H. STEENBOCK, Dept. Biochem., Univ. Wis., Madison. Jour. Biol. Chem., *147*, No. 1: 65. 1943.

Vitamin D was added to a "synthetic" ration optimal for growth in its content of phosphorus and calcium and of known iron content, for rats. When fed, there resulted an increase in hemoglobin and especially in the total amount of body iron in rats. Although vitamin D had no effect on body weight, it produced a marked increase in the weight of the liver. In contrast to the beneficial effect on the storage of iron, vitamin D had no effect on the storage of copper. K.G.W.

## ICE CREAM

319. **Wartime Mixes.** P. H. TRACY, Univ. Ill., Urbana. Ice Cream Trade Jour., *39*, No. 2: 16. Feb., 1943.

A scarcity of milk products for ice cream making has stimulated research for the purpose of finding substitute materials. The use of vegetable fats, cereals and solids from corn syrup has been tried. Some of these products made acceptable ice cream, however, the use of cereal and vegetable solids will require legal sanction. W.H.M.

320. **Lower Fat Trends.** EDITOR, Ice Cream Trade Jour., *39*, No. 4: 10 Apr., 1943.

The following states have taken action to reduce the minimum butterfat requirements for ice cream. Most of the laws are for the duration of the war or for a specified period thereafter.

| *State* | *Old (% fat)* | | *New (% fat)* | |
|---|---|---|---|---|
| | *Van.* | *Fruit & Nut* | *Van.* | *Fruit & Nut* |
| Oregon | 12 | 10 | 8 | 6 |
| Wyoming | 12 | 10 | 8 | 8 |
| Michigan | 12 | 10 | 10 | 8 (French custard 12) |

| | | | | |
|---|---|---|---|---|
| Vermont | ..... | ..... | 8 | ... |
| Idaho | 14 | 12 | 10 | 8 |
| Delaware | ..... | ..... | 10 | 8 |
| Wisconsin | 13 | 11 | 10 | 8 |
| Iowa | 12 | 10 | 8 | 6 (nut 7) |
| Nebraska | 14 | ..... | 8 | ... |

W.H.M.

**321. Wartime Mixes.** THEO. R. FREEMAN AND E. L. FOUTS, Fla. Agr. Expt. Sta., Gainesville. Ice Cream Trade Jour., *39*, No. 4: 20. Apr., 1943.

Several materials were used in ice cream as substitutes for part of the serum solids. Among the materials used were wheat flour, soyflour No. 1 and soyflour No. 3. With the exception of wheat flour all the products used produced a distinct, but not particularly unpleasant, flavor to the ice cream and were not suited to use in vanilla ice cream. The flour in amounts of 1, 2, and 3%, was mixed with dry skim milk and sugar and added to the other ingredients of the mix at 110° F. and then the mixture was heated to 160° F. for 30 minutes. Excessive viscosity was encountered in some of the mixes containing flour. Reduction in the amount of stabilizer used in the mixes containing flour made it possible to overcome the excessive viscosity. One tenth of one per cent stabilizer was used with 2% flour and no stabilizer in the 3% flour mix.

Ice cream containing oat flour compared favorably in flavor and body and texture to the ice cream containing 3% wheat flour, however, the ice cream containing 2.5 to 3% oat flour was inferior in flavor. W.H.M.

**322. A Comparison of Some Ice Cream Stabilizers.** DONALD V. JOSEPHSON, CHESTER D. DAHLE, AND STUART PATTON, Penn. State Col., State Col., Penn. South Dairy Prod. Jour., *33*, No. 4: 34. Apr., 1943.

Thirteen stabilizers were tested in a standard mix containing 13% butterfat, 11% serum solids, 15% sugar. Cream, condensed skim milk, skim milk and cane sugar were the basic ingredients. Tests made included 118 mixes processed over a period of one year.

The following characteristics of the stabilizers are mentioned: (1) A mix containing gelatin should be aged three to four hours before freezing. Too much gelatin may result in the formation of a gel and as a consequence there may be difficulty in handling the mix. The gel strength of the different grades varies widely. (2) When "Dariloid" is used a minimum pasteurizing temperature of 160° F. is required for maximum efficiency. Standardization of acidity or the use of Dutch process cocoa in such mixes may cause thickening on the cooler. (3) "Kremtex," a new stabilizer, imparts

very desirable body and texture characteristics to ice cream. It produces a very low viscosity in the mix. Care must be taken to prevent the highly hydrated gelatinous particles of the stabilizer from clogging the pores of the homogenizer screen. (4) "Kremtex" 53 is similar to "Kremtex" but imparts a somewhat higher viscosity to the mix. (5) "Oat Gum" has excellent possibilities. It is cheap, imparts desirable characteristics to the mix and ice cream and has antioxidant properties. About 0.5% is required for stabilization. A small amount of sediment from the material settles out of the mix upon standing in the mix tank but is readily dispersed by agitation and is of no significance in the finished product.

(6) "Baiz" produces ice cream with desirable body and texture. It is easily incorporated. The resulting mix possesses relatively high viscosity but causes no significant problem. (7) "Kragel" reacted similarly to "Baiz" but did not maintain as desirable body and texture in the ice cream as did the others listed above when 0.35% was used. (8) "Vestirine" is similar to gelatin in viscosity characteristics. It enhances whipping and maintains very desirable body and texture in ice cream held at cabinet conditions (0.4% was required). A considerable quantity of "oily" or "fatty" material collected on the surface of the mix during pasteurization requiring thorough agitation in the pasteurizer. (9) "Articol" had satisfactory stabilizing action when 0.225% was used. The mix tended to incorporate air bubbles which disappear on standing. (10) "Cer-O-Gel" used on a 50–50 basis with gelatin was not particularly outstanding as a stabilizer. (11) "Algin" was found to lack stabilizing action and is not recommended for ice cream mixes. (12) "Gum Karaya" is lacking in stabilizing ability. (13) "Methocel" (4000) is definitely lacking in stabilizing ability. "Whey-ing off" invariably resulted when the mix stood undisturbed for 24 hours.

F.W.B.

**323. Conserving Milk Solids.** C. D. Dahle and D. V. Josephson, Pennsylvania State Col., State Col., Pa. Ice Cream Field, *41*, No. 4: 12. Apr., 1943.

Because of restrictions on the use of milk solids in ice cream, manufacturers are required to make low solids products or use substitutes to compensate for these limitations, the authors claim. Results of experiments are given in which cereal products are used in concentrations from 1 to 2½% in a basic mix containing 10.5% fat, 8.4% serum solids, 15% sugar and 0.3–0.4% stabilizer.

The authors claim that the use of 1% Avenex (oat flour) and other flours in ice cream improves the body considerably. It was also shown that when more than 1½% of these products was used, that a cereal flavor resulted. The authors increased the amount of flavor added along with the increase in cereal products used as a means of partly masking the undesirable flavor.

In certain cases, the texture was improved by up to 2% concentration with these products, but the desired overrun was obtained with increased difficulty as the concentration was raised above 1½%. W.C.C.

**324. Sherbets and Ices to the Fore.** KEN FORREST, Merchandising Editor. Ice Cream Field, *41*, No. 3: 28. Mar., 1943.

As an aid to manufacturers, the author lists ten formulas for ices and sherbets, obtained from J. H. Erb of Ohio State University and from several flavor supply firms. W.C.C.

**325. Production of Sherbets and Ices.** P. H. TRACY, Dept. Dairy Husb., Univ. Ill, Urbana. Ice Cream Field, *41*, No. 3: 10. Mar., 1943.

After defining ices and sherbets, the author discusses the functions of stabilizers in these products. Several stabilizers are briefly described and directions given for the use of gelatin, agar, gum arabic, India gum, Karaya gum, pectin, and carob bean products.

For ices and sherbets 26%–30% sugar is recommended with 25%–50% of the sugar as monosaccharides. Brief directions are given for preparing invert sugar from sucrose. When 25%–29% sugar is used, the author recommends 0.35%–0.40% citric acid; with 30%–35% sugar, he recommends 0.40%–0.45% citric acid.

The proposed Federal standards gives 4% milk solids as the minimum for sherbets, but there is considerable variation in the amount used commercially, it is stated.

The following defects in ices and sherbets are listed and briefly discussed: bleeding, surface crustation, crumbly body, hard body, snowy body, coarse body, and sticky body. Four suggested formulas are given for ices and sherbets. Special mention is also made of buttermilk sherbet or Lacto, developed several years ago at Iowa State College. W.C.C.

**326. Ice Cream Rationing and the Dealer.** VINCENT M. RABUFFO. Ice Cream Trade Jour., *39*, No. 3: 10. Mar., 1943.

Since the rationing of ice cream has become necessary, the Carnation Company has developed a program for its dealers to follow in the operations of their fountains. Dealers have been advised to set up a daily quota and to take an inventory every three days so that they may establish their weekly position. A check on hourly sales should be made and this information can be used as a basis for making changes in operation and for determining the amount of labor needed. In the carry-out department dealers are asked to set a maximum amount of ice cream per customer and to push packaged ice cream and require a customer to purchase some sherbet. When other methods fail, it may be desirable to reduce the size of the servings so that more customers may be served. Employees can be trained to watch weights when dipping, to avoid over-dipping, to have ice cream at the proper temperature for dipping and to keep spades and dippers sharp.

In one store, after an analysis of hourly sales it was possible by operating the store 9 hours instead of 16 to make a 40 to 45% saving in labor and still sell 73% as much ice cream. Seven days operation with 8 hours was found to be better than five 16-hour days. It was found inadvisable to discontinue carry-out business, since a survey showed that it would result in a 40% reduction in gross margin with only a 16 to 20% cut in selling expense. This company believes that dealer guidance is essential if its dealer organization is to be intact for post-war merchandising. W.H.M.

**327. Selling Sherbets.** GEORGE W. HENNERICH, Ice Cream Merchandising Institute, Washington, D. C. Ice Cream Trade Jour., *39*, No. 3: 20. Mar., 1943.

The ice cream industry is turning to the sale of sherbets as a means of extending the volume of ice cream which it has to sell. To do this successfully requires some effort on the part of the merchandiser since the consumer has developed a taste for ice cream and may not care for sherbets. The use of part ice cream and part sherbet in making sodas and milk drinks is suggested. Correct cabinet temperatures for holding sherbets should be worked out so that the product will be in the proper condition for serving. W.H.M.

**328. Producing Sherbets for New Volume.** B. I. MASUROVSKY, Res. Editor. Ice Cream Trade Jour., *39*, No. 2: 14. Feb., 1943.

Interest in the manufacture of sherbets and ices has been greatly stimulated, since the amount of ice cream which can be manufactured has been curtailed by Food Distribution Order No. 8.

The following formula is suggested for a milk sherbet: milk solids, 5%; cane sugar, 14%; corn sugar, 14%; water, 66.5%; stabilizer, 0.5%.

In the manufacture of sherbets it is advisable to regulate the sugar content and amount of fruit used, the sugar available, and the amount of overrun taken on the sherbet.

A formula for sherbets proposed by Prof. C. D. Dahle, Penn. State Col., is as follows: 16–20 lbs. skim milk; 14 lbs. total sugar or 10.5 lbs. cane sugar and 3.5 lbs. corn sugar or its equivalent; 3–3½ oz. stabilizer.

Fruit, water, acid, color to make 5 gals. The sugar content of the fruit should be known and subtracted from the 14 lbs. as this is the amount of total sugar. W.H.M.

## MILK

**329. Controlling Flavor in Market Milk.** P. H. TRACY, Univ. Ill., Urbana. Internatl. Assoc. Milk Dealers Assoc. Bul., *35*, No. 9: 139–145. Feb., 1943.

The recent more liberal use of milk as a beverage has caused the factor

of flavor to assume a greater importance in milk quality. Common causes of milk flavor defects are discussed. The chemical cause of medicinal flavor has not been determined but chlorine sterilizers left too long in contact with wet metal surfaces seem to produce the flavor. This means the first milk coming in contact with such a surface may carry the flavor strongly. A safe procedure is to rinse equipment with water after treatment with chlorine. Cold milk will have a more pleasing flavor, and this means of causing milk to be better liked should receive more attention. E.F.G.

**330. Controlling Defects in Bottled Cream.** H. H. SOMMER, Univ. Wis., Madison. Internatl. Assoc. Milk Dealers Assoc. Bul., *35*, No. 19: 263–271. Mar., 1943.

One of several defects of special interest in bottled cream is rancidity. The greater difficulty with this defect in winter is thought not to be due so much to a greater lipase content in that season as to more favorable lipase activation temperatures and treatment in handling. When difficulty with rancidity is experienced separation should be at high enough temperature to melt the fat completely, usually 104–110° F.

Cream plug is due to agglomerations of fat globules containing 55 to 80% pure fat which in a solid condition obstructs the top of the bottle. This partial churning is due to too much agitation at temperatures favorable for churning, especially 60–85° F. but also through the entire range from 50 to 110° F. Skim milk layer usually appears in 18% cream and becomes less likely as the fat content approaches 25%. With 25% cream, fat clumping evidenced by viscosity may be encouraged until fat globules and clumps touch one another and no cream rising will take place. In 18% cream not enough fat is present for this and better results will be obtained by injuring creaming ability so that enough fat will remain in the skim milk layer to cause it to be indistinct. Adding a little homogenized milk, higher separating and pasteurizing temperatures will do this. Complete control between 18–20% fat cream almost requires homogenization of the cream. Feathering in coffee is due to coagulated protein floated to the surface by the fat included in the curd particles.

The high acidity, temperature or salt balance of the coffee may be to blame or cream may be responsible due to acidity, salt composition, pasteurization temperature or homogenization. The use of soft water in coffee making and 2–6 oz. sodium citrate per 1,000 lbs. of cream may correct the salt condition. Pasteurize at 158–165° F. and prevent fat clumping in homogenization. (As by double stage homogenization.)

Viscosity is a problem of controlling clumping of the fat globules. Rebodying of cream is done by heat treatment and gentle agitation. Too much agitation causes partial churning and cream plug. The rebodying must be carefully done under controlled conditions in order to secure uniform vis-

cosity. Mixtures of untreated and rebodied cream may give the desired results. E.F.G.

**331. Merchandising Milk through Stores.** DOUGLAS YOUNG, Qualitee Dairy Products Co., San Diego, Calif. Internatl. Assoc. Milk Dealers Assoc. Bul., *35*, No. 18: 251–257. Mar., 1943.

Efforts of the milk dealer to quickly secure a large volume of business have frequently been responsible for his developing store trade. Store milk starting at the same price as home delivered milk soon experienced reductions of one and two cents below the home delivered price as the chain store operator found this induced customers to come to the store more frequently and stimulated sales of more profitable items. The stores frequently made unreasonable service demands, did not take good care of the product and sought special discounts.

The percentage of milk sold in stores has increased from 25 to 60–65. "Dairy Stores" started 10 or 12 years ago during the depression are declining because of their owner's inability to get cheap help, better purchasing power of the housewife and other reasons. Along with the prospect that more reliance may need to be placed upon stores as tires and delivery equipment wear out, comes the fact that many neighborhood stores are closing for lack of help and other complications so that the housewife has greater trouble in getting store milk.

The question is raised whether the proportion of home delivered milk will be so small in the post-war period that it will be too expensive for all but the few or will the customer be so out of patience with the inconveniences of store milk that there will be a strong swing back to home delivery. E.F.G.

**332. The Universal Milk Bottle.** R. B. STOLTZ, Ohio State Univ., Columbus. Internatl. Assoc. Milk Dealers Assoc. Bul., *35*, No. 17: 227–248. Mar., 1943.

The advantages of the universal bottle include: (1) elimination of the bottle exchange, (2) no sorting of bottles, (3) purchase at lowest price, (4) longer bottle life, (5) opportunity for closer cooperative distributor relationships, and (6) more satisfied retailers. Low bottle costs are dependent upon the following: (1) a bottle deposit, (2) elimination of bottle exchange, (3) everyone from plant employees to customer must be conscious of bottle losses, and (4) the universal bottle. Ohio State University has collected data for 29 dairies in cities with bottle exchanges and 24 dairies in cities without, with the following results:

| | *1940* | | *1941* | | *6 mo. 1942* | |
|---|---|---|---|---|---|---|
| | *Trips* | *Cost* | *Trips* | *Cost* | *Trips* | *Cost* |
| Bottle exchange dairies | 25.1 | $2.96 | 28.5 | $2.67 | 20.4 | $3.11 |
| Non-bottle exchange dairies | 46.1 | .90 | 57.9 | .80 | 48.0 | .89 |

The elimination of the bottle exchange gives higher trippage and cuts the cost of filling bottles by two-thirds.

The city of Columbus has used the universal bottle since 1934 with an average trippage of 50 and a cost of less than 75¢ per 1,000 bottles filled. In 1940 the 17¾-oz. 48-mm. bottle was adopted. As trippage is pushed to higher levels, costs for this extra trippage tend to exceed the savings. A form used for universal milk bottle license by a milk distributors association which owns all bottles is given. Also the rules and regulations of the same association are printed in full. E.F.G.

**333. Quality Control Problems Imposed on Field Inspectors by the Wartime Emergency.** H. E. BREMER, Vt. Dept. Agr., Montpelier, Vt. Internatl. Assoc. Milk Dealers Assoc. Bul., *35*, No. 16: 219–223. Mar., 1943.

Inexperienced help on dairy farms has been so inefficient that in general dairy farmers have preferred to reduce production rather than attempt to use it. One milk company has had a 40% increase in number of milking machines used by its patrons during the last year. Effective ways of impressing the importance of proper milking machine care upon green employees are important. Less frequent delivery and other distribution savings have placed greater emphasis on the need for a better quality milk supply. E.F.G.

**334. Resazurin Reduction at 18° C.** B. F. THOMAS, Univ. Col. of Wales, Aberystwyth. Proc. Soc. Agr. Bact. (Gr. Britain). p. 27. 1942.

A comparison of resazurin reduction in milk at 37° and 18° C. was carried out on a series of 360 samples of market milk. The incubation time at 18° was 1½ to 2½ times that at 37°. Poor quality milk samples reduced quickly at 18°. For example, 82% of the samples reducing to white within 1 hour at 37° reduced to this stage within 2 hr. at 18°, and 96% of the samples which reduced to white within 10 minutes at 37° reduced to the same stage within 30 minutes at 18°.

The results show that resazurin reduction in milk at 18° is well worth further investigation since it would appear that a reliable indication of the keeping quality of milk at this temperature can be obtained within 2 hours while samples of really poor keeping quality can be detected within 30 minutes. It is suggested that examination of the tubes after 30 minutes and after 2½ hours at 18° would give results fairly similar to those obtained with the 10-minute and 1-hour resazurin test at 37°. M.W.Y.

**335. A Comparison of Rapid Platform Tests for the Bacteriological Quality of Milk.** H. BARKWORTH, J. G. DAVIS, J. W. EDGELL, A. ROWLANDS, AND D. W. WATSON. Proc. Soc. Agr. Bact. (Gr. Britain). p. 25. 1942.

The following tests and techniques were selected for investigation: (1)

smell and taste, (2) clot on boiling, (3) alizarin-alcohol, (4) titratable acidity, (5) 10-minute resazurin test, (6) pH (glass electrode). It was concluded that the 10-minute resazurin test was the test most suited for rapid weeding out of unsatisfactory samples on the receiving platform. An important aspect is the flexibility of the 10-minute test which can be varied in standard by choice of disc reading which in practice is a point of some importance. M.W.Y.

**336. Recent Developments of the Resazurin Test.** J. G. DAVIS, Natl. Inst. Res. Dairying, Univ. Reading. Proc. Soc. Agr. Bact. (Gr. Britain). p. 20. 1942.

Resazurin has been synthesized by Baker and Leeds at Oxford and by Short and Oxley at Nottingham. Eastman Kodak, National Aniline, Benger's (Baker and Leeds' synthesis) and Boots' (Short and Oxley's synthesis) preparations are all satisfactory and when tested in different milks agree within ½ of a disc reading. The purity of samples is most easily tested by an immediate comparator reading in low count milk.

The stock (0.05%) solution is prepared by dissolving 100 mg. of the preparation in 200 ml. distilled water, boiling for ½ hour (in the dark) and thereafter the solution is maintained in the refrigerator under aseptic conditions. The comparator should always be used if possible. Neither resazurin nor methylene blue pick out high count milk in 1 hour in cold weather, and Davis and Thomas have suggested a scale for times of incubation for routine grading which ranges from 120 minutes at 37.5° C. when the mean atmospheric temperature for the 24 hours following production is 40° F. or less to 15 minutes when it exceeds 70° F.

The following special forms of the test are in use and under investigation: (1) The rapid resazurin test, originally 5 minutes at 45° C. and modified in 1941 to 10 minutes at 37.5° C. This is a sorting out test for the creamery platform to detect bad milks and must not be used for routine grading. (2) The resazurin-rennet test. This is especially useful for single-cow or quarter samples and is unsuitable for bulk milk. (3) The resazurin test at 18° C. for keeping quality. M.W.Y.

**337. The Ten Minute Resazurin Test.** S. B. THOMAS AND G. M. PHILLIPS, Univ. Col. of Wales, Aberyswyth. Proc. Soc. Agr. Bact. (Gr. Britain). p. 22. 1942.

The National Milk Testing and Advisory Scheme, which has been in operation in England and Wales since June 1, 1942, has brought about the much needed standardization of the methods of milk sampling and bacteriological testing at creameries. Every churn of milk on arrival at the creamery is checked by the platform examiner, and milk which has any abnormal smell or taste is examined by means of the 10-minute test. When

the resazurin disc reading at 10 minutes is 4 or higher, the milk is accepted, when 3½ to 1 inclusive it is salvaged if possible, otherwise rejected while a disc reading of ½ and 0 results in rejection. Results of comparisons with the methylene blue test and a number of other quick tests are given in this paper. Only 50% of the samples reducing to a stage halfway between discs and 0 and 1 were detected by smell. M.W.Y.

**338. Dairy Industry in Canada Meets Wartime Problems.** J. H. DUPLAN, Silverwood Dairies, Ltd., London, Ontario, Canada. Internatl. Assoc. Milk Dealers Assoc. Bul., *35*, No. 12: 167–171. Mar., 1943.

A Government subsidy was provided for the period December, 1941, to April, 1942, for the market milk producer at 30¢ per cwt. and for milk for the manufacture of concentrated products at 40¢ per cwt. A bonus of 1¢ was provided for 93 score cheese and 2¢ for 94 score. The subsidy on butter was first 6¢ and later increased to 10¢ per lb. On September 1st, consumer ceiling prices were fixed at the highest prices in each market during the period of September 15 to October 12, 1941. At the same time producer prices were raised 10¢ to 20¢ per cwt. Another 6¢ was added later also borne by the distributor. To this was added a government subsidy of 25¢ per cwt. New producer prices ranged from $2.05 for a 11¢ per quart retail price to $3.15 when the retail price became 15¢.

Economies have been effected by: elimination of special deliveries, special bottle caps, quarter pint bottles, and returns from both wholesale and retail customers; the introduction of a 5¢ deposit bottle, daylight route delivery and a strictly cash policy for sales; restriction of cream to two grades (12 and 33%); one distributor service to each wholesale account; and general reduction in truck mileage. Prospective changes are a universal bottle, every-other-day delivery and limiting fat percentage to 18% in all cream. E.F.G.

**339. Emergency Use of the Laboratory During War.** W. L. MALLMANN, Mich. Agr. Expt. Sta., East Lansing. Internatl. Assoc. Milk Dealers Assoc. Bul., *35*, No. 13: 175–188. Mar., 1943.

Three methods of determining thermoduric bacteria in milk are described: (1) the laboratory-pasteurization plate method, (2) the two-hour pasteurization microscopic test, and (3) the autoclaved slide test. An analysis of 46 producers showed nine samples containing many thermoduric bacteria. That the udder is not an important source of thermoduric bacteria is shown by the fact that of 90 samples collected aseptically, only six showed thermoduric bacteria averaging 15 per ml. The bacteria from the udders of five animals suffering from streptococcic mastitis did not in any case survive pasteurization. In general contamination with thermoduric bac-

teria can be charged to dirty equipment. The two-hour pasteurization microscopic test is useful because after about two hours the dead cells have all disappeared and do not stain and the thermophylic bacteria have not yet started to multiply rapidly. The count at that time parallels closely the plate count and presumably is a good measure of the thermoduric bacteria in the sample.

A simplification of the two-hour pasteurization microscopic test is the autoclaved slide procedure. This method is based upon the fact that a slide autoclaved for 10 minutes at 15 lbs. pressure will have about as many stainable cells as when the plate method or the two-hour pasteurization microscopic method is used. Longer periods of heating, however, produced a decrease in numbers of cells. Thermoduric bacteria (gram positive) will remain intact after death induced by heating at 15 lb. pressure for 10 min. With this method samples showing 40,000 or more bacteria per ml. are reported as containing thermoduric bacteria in excessive numbers. By this test the relatively small numbers of producers whose milk is heavily seeded with thermoduries can be located and effort concentrated on them. This is a time saver for the busy plant man. E.F.G.

**340. The Flavor of Market Milk.** J. A. NELSON, Montana State Col., Bozeman, Mont. Mont. Agr. Expt. Sta. Bul. 410. Mar., 1943.

Samples of raw and pasteurized milk (151 of each) were studied during October through May of the four-year period 1938–1941. The milk was pasteurized in a stainless steel vat at 143° F. for 30 minutes and cooled over a tinned surface cooler. It was found that an oxidized flavor developed in much of the milk after pasteurization. The addition of pancreatic enzyme before pasteurization retarded, but did not prevent the oxidized flavor development. The flavor of the pasteurized milk in general deteriorated to a greater extent during storage than did the flavor of the same milk unpasteurized. Pasteurization aided in the removal of feed flavors.

P.H.T.

**341. Consumption of Milk and Some Other Dairy Products in Metropolitan New Jersey.** E. H. RINEAR. N. J. Agr. Expt. Sta. Bul. 702. Oct., 1942.

This survey was made during March, April and May, 1941, in four urban centers subject to the same price regulations. In all, 1,013 usable records were obtained. Comparisons in consumption of milk and other dairy products were based on an income range of $500. The results of the study show that there is a direct relation between the amount of fresh milk and other dairy products consumed and the family income. The consumption of fresh milk tends to increase as the family income increases from $500 to $2,500. Most of these families supplement their milk supply with evaporated milk,

but the proportion of evaporated used decreases as the family income increases. It is of interest to note that the consumption of fresh and evaporated milk combined in families with low incomes approaches the same level as the combined consumption of families of higher income. The consumption of cream is affected more than milk by the family income. In the higher-income groups, the increase in cream consumption per member is much greater than the increase in milk consumption. The consumption of butter also increases with the family income level.

On the average, adults in families without children consume more fresh milk than adults in families with children. In general, the information obtained indicates that growing children of families with low incomes are not consuming enough milk to maintain satisfactory standards of nutrition.

A large proportion of the consumers who were in favor of quantity discounts and larger store differentials had incomes below $1,500.

If the trend of consumption of evaporated milk should continue upward, the dairymen who are supplying fresh milk for immediate consumption may find that they have a continued decreasing demand for their product. However, if new ways of distributing fresh milk are developed which will reduce the cost to the consumer, the indications are that farmers can hold or even increase their markets for fresh milk. P.H.T.

**342. Quality Control for the Plant too Small to Have a Technical Laboratory.** ROBERT S. BREED, N. Y. Agr. Expt. Sta., Geneva. Internatl. Assoc. Milk Dealers Assoc. Bul., *35*, No. 10: 152–156. Feb., 1943.

The laboratory covers three main fields of activity: (1) Protection of the dealers against inferior supplies such as cleaning and sterilizing agents, cans, bottles, caps, etc. (2) Protection against inferior quality of milk from producers. (3) Control of plant processing. Where technical laboratory service is not available it is suggested that the plant operator himself make simple tests such as smelling the milk and the use of the phosphatase test. It is suggested that if the dealer himself cannot operate a control program that he obtain assistance from outside private sources or from his city health department which is usually glad to cooperate. Another source of help is the privately operated technical control laboratory often found in many cities. E.F.G.

## PHYSIOLOGY

**343. Effects of Pituitary Gonadotropins on the Ovaries and the Induction of Superfecundity in Cattle.** L. C. CASIDA, R. K. MEYER, W. H. MCSHAN, AND WALTER WISNICKY, Univ. Wis., Madison. Amer. Jour. Vet. Res., *4*, No. 10: 76. Jan., 1943.

*Calves:* The ability of calf ovaries to respond to gonadotropins was indi-

cated by the presence of, but was not dependent upon, vesicular follicles. Corpora lutea formation, following injection of unfractionated pituitary extracts, depended upon the duration of treatment rather than upon a minimal ovarian or follicle size. Simultaneous injection of theelin or hemin did not alter this response.

FS extracts subcutaneously followed by LH intravenously caused superovulation. FSH caused simultaneous rather than selective follicle development. Subcutaneous injections alone caused no corpora lutea to be formed in six days.

Purified FSH subcutaneously followed by intravenous injections usually produced normal corpora, probably because of the luteinizing action from the calves' own pituitaries. Examination of these excessively stimulated ovaries 40 days after treatment indicated ability to return to normal or near normal function.

*Cows:* FSH and/or unfractionated extracts given subcutaneously to normal cows in different stages of the estrus cycle, and in pregnant and nonpregnant animals, tended to cause a large increase in ovarian weight as compared to normal. Corpora lutea were formed in some cases. In the pregnant cows, no disturbance of pregnancy could be found when the animals were autopsied six days after the beginning of the treatment. Heme did not augment the effect of the pituitary extracts, but the average diameter of the follicles in the heme-treated group tended to be smaller in diameter; possibly a larger number of follicles were stimulated.

Three-gram equivalents of unfractionated extract given subcutaneously to two cows for 35 and 40 days respectively caused the production of antihormones in 21 and 36 days. The greatest antihormone concentration in one occurred at 30 days. Anorexia and ascites developed in both cows after prolonged treatment. Possibly this condition is inhibited by antihormones. Ovaries of these two animals at autopsy weighed 1425 and 1440 grams, respectively, and they contained many cysts and partially luteinized cysts.

In normal cows, unfractionated extracts subcutaneously and intravenously produced corpora in pregnant animals, but they did not endanger pregnancy. Unfractionated extracts producing excessive numbers of follicles were incapable of inducing estrus unless also treated with estrogen. These extracts tended to delay the next natural heat period. None of these cows became pregnant when force bred following the intravenous injection.

Subcutaneous and intravenous injections of purified FSH tended to hasten estrus in some cows and to produce corpora, probably because of the added effect of the animals' own pituitaries.

Cows in early estral period, when injected subcutaneously with purified FSH and intravenously with LH, usually ovulated but did not become pregnant when inseminated at the end of the injection period. The effect on the following estral period varied. In another group treated in the same

way at the 16th to 18th day of the cycle, 4 of 7 became pregnant. Four to 7 embryos were found and the ovaries contained 4 to 9 corpora. Natural ovulation stimulus was no doubt present in addition to the artificial stimulation. There was evidence of early fetal death in these cases of superfecundation.

Five and three eggs respectively were recovered from two cows treated subcutaneously and then intravenously with unfractionated extracts.

S.A.F.

**344. Experimental Alteration of Thyroid Function in Cattle.** J. F. BULLARD AND F. N. ANDREWS, Lafayette, Ind. Jour. Amer. Vet. Med. Assn., *102*, No. 794: 376. May, 1943.

Thyroidectomy of eleven steers ranging in age from 3 to 18 months resulted in a consistently accelerated rate of gain during the first four to six weeks after the operation. Rate of gain then decreased until time of slaughter at from 20 to 26 weeks postoperatively. Thyroid weights at time of removal ranged from 17.1 to 51.8 gms., while at slaughter from 6.9 to 102.4 gms. of thyroid tissue were recovered from each of ten animals. In only one case was complete removal accomplished. Thyroid therapy was necessary to carry this animal through to slaughter date. Histological examination of thyroid tissue removed at autopsy showed it to be in a state of hypertrophy. S.A.F.

**345. The Utilization of B-Hydroxybutryic Acid by the Perfused Lactating Mammary Gland.** J. C. SHAW AND W. E. PETERSEN. Dept. Dairy Indus. Storrs Agr. Expt. Sta., Storrs, Conn., and Div. Dairy Husb., Univ. Minn., St. Paul. Jour. Biol. Chem., *147*, No. 3: 639. 1943.

This study confirms a previous finding that the lactating mammary gland utilizes B-hydroxybutyric acid, and further, that the quantity of this substance metabolized by the gland, perfused with blood containing large quantities of the substance is considerably in excess of that utilized by the gland of the normal cow and is independent of blood sugar level. It is believed the gland oxidizes the substance for energy purposes. K.G.W.

**346. A New Method for the Preparation of Prolactin.** E. SCHWENK, G. A. FLEISCHER, AND S. TOLKSDORF. Chem. Res. Lab., Schering Corp., Bloomfield, N. J. Jour. Biol. Chem., *147*, No. 3: 541. 1943.

Fresh macerated pituitaries are treated with chloroform at pH 5.0–6.0 and centrifuged. The pituitary proteins are separated into two fractions, one of which is soluble in water, containing the gonadotropins and thyrotropin, and one which is a solid gel, containing prolactin and adenotropin. The separation of prolactin from the chloroform gel is accomplished by

extraction with acid methanol and sodium chloride fractionation. A final product of 30 I.U. per gram is obtained. K.G.W.

**347. The Cow's Udder and Its Activity.** W. E. PETERSEN, Univ. Minn., St. Paul. Internatl. Assoc. Milk Dealers Assoc. Bul., *35*, No. 14: 191–198. Mar., 1943.

The structure of the mammary gland is described in detail followed by a discussion of the many hormones concerned with mammary growth and milk secretion. The equilibria phenomena between blood and milk are illustrated by the fact that lactose will pass from the udder into the blood and chlorides from the blood into the udder. When milk has been in the udder longer than usual a maximum pressure will be built up and this exchange of substances then takes place. Abnormal mastitis milk is produced largely by this phenomenon. The reaction to brom thymol blue in case of mastitis is due to sodium bicarbonate passing from the blood into the milk. The high chloride and low lactose of mastitis milk is accounted for by the exchange of chloride of the blood for lactose of the milk. Many materials pass directly from the blood into the milk until the concentration in both is the same. The strong flavor of some feeds does this.

When milk is left in the udder until the pressure becomes about one-fourth that of blood then milk secretion ceases. Increased yields in the case of three- and four-time milkings are due to keeping the udder pressure low.

The let down of milk is the result of a reflex, that is an unconscious spontaneous act and many factors will affect its normal operation. For most successful milking the process should be begun one or two minutes after the cow's udder has been prepared and completed within about four minutes. Cows can be trained to let down all the milk by machine so that no stripping is needed. Good operators with four units have milked 50 cows or more per hour. E.F.G.

## MISCELLANEOUS

**348. Dairy Detergents.** A. T. R. MATTICK, E. R. HISCOX AND J. G. DAVIS, Natl. Inst. Res. Dairying. Shinfield, Milk Indus., *23*, No. 8: 33. Feb., 1943.

The authors state that the great value of detergents in all washing processes has led to the synthesis and appraisement of large numbers of compounds in recent years. This discussion is a review of articles on dairy detergents from 1939 to 1941 listing 24 references, more than half being of foreign origin. They summarize articles on milk stone, care of operating, corrosive action, chlorine sterilizers, spraying glass-lined tanks, use of chlorine preparations on the farm and infection of milkers' hands. H.P.

**349. Cutting Corners in Accounting Routine without Jeopardizing Internal Control.** WILLIAM C. BUNK, Golden State Co., Ltd., San

Francisco, Calif. Internatl. Assoc. Milk Dealers Assoc. Bul., *35*, No. 15: 203–215. Mar., 1943.

General and cost accounting should not take over 5% of the total office time the bulk of the time being spent on accounts receivable, sales recapitulation, checking of drivers, balancing product and the like.

Sales recapitulation which generally absorbs 10–15% of the total office time lends itself well to "peg board" treatment which reduces the time for this operation. Accounts receivable using 15–20% of the total office time cannot be eliminated as the customer must have his statement but the accounts receivable ledger which consumes so much time can be eliminated and a duplicate copy of statements used in its stead.

It is suggested that the operating ledger can readily be replaced by an operating summary. The general summary is handled in the same way. These have been used for several years and greatly facilitate accounting work saving about one-third in the time and enabling less experienced persons to do the work. Auditing for accuracy may be distributed among the various people in the office without much extra time being used while the office manager has proven to be an excellent person for the integrity audit. E.F.G.

**350. Researches on Industrial Lighting.** OLE A. HILL, JR., Pub. Service Co. of Northern Ill., Joliet, Ill. The Internatl. Assoc. of Milk Dealers, Assoc. Bul. *35*, No. 7: 103–122. Jan., 1943.

The studies reported were made by the Illuminating Engineering Society in cooperation with the International Association of Milk Dealers, the Dairy Industries Supply Association, Inc., and the Glass Container Association of America. The benefits of good illumination are less breakage, improved cleanliness, better utilization of floor space and less eye strain. A table presents recommended minimum operating foot candles in service for each room and the different processes in the milk plant. These range from 10 foot candles for bottle rooms, loading platforms, etc., to 50 foot candles for bottle sorting, filling and inspection, laboratories, etc. A general room illumination of 20 with supplementary lighting to total 50 at points needed is recommended. Special lighting on thermometers, scales, gauges, etc., should total 30. Special treatment is needed for bottle inspection. An inspection box is proposed which would be a luminous panel incorporated into the unloading mechanism. This would use fluorescent lamps and give a glareless, shadowless, silhouetting which is very effective. Several photographs and drawings show applications. It is stated that purely local lighting restricted to a small work area is unsatisfactory unless there is sufficient general illumination. A ratio of 1 to 5 in the above is considered good practice. It may be necessary sometimes to allow twice the wanted illumination to provide for loss of efficiency due to lack of maintenance. E.F.G.

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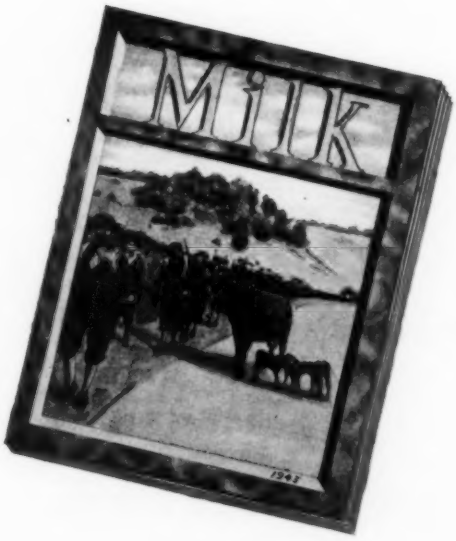


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